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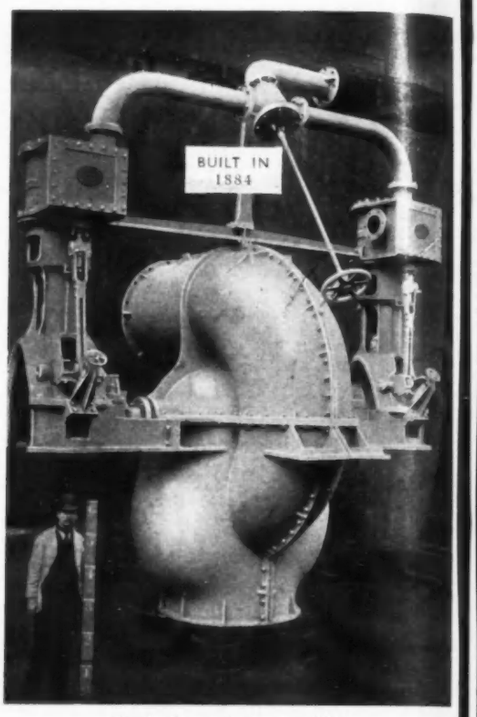

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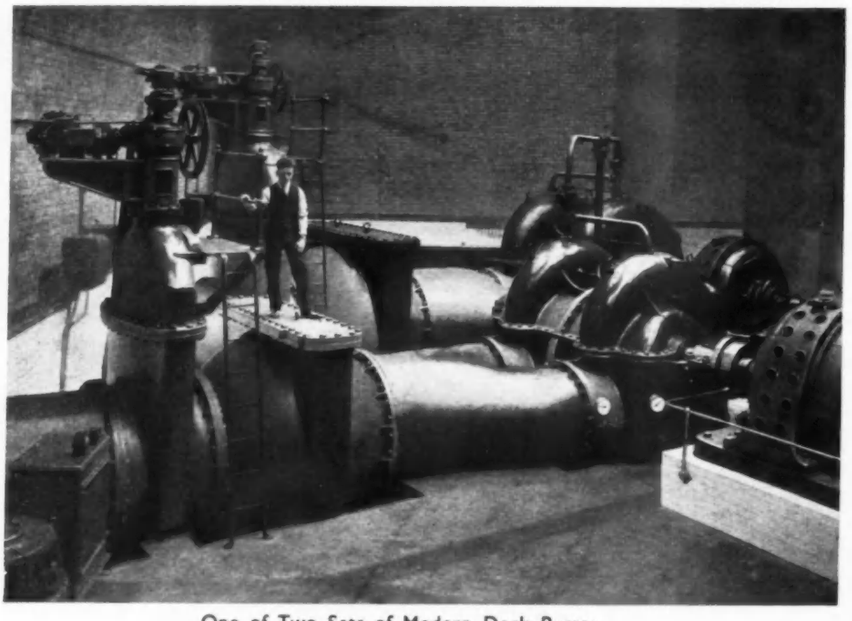

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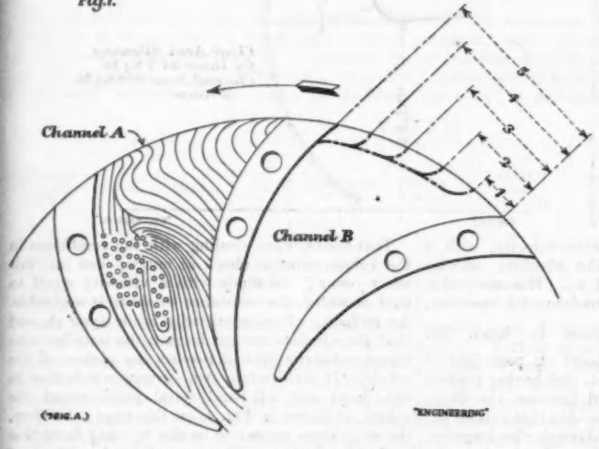
THE FLOW THROUGH CENTRIFUGAL PUMPS.

By G. URE REID.

THE text-book theory of centrifugal pumps assumes that the fluid must approach the impeller channels radially, must fill them completely, and must be discharged uniformly round the outer circumference; but it is not generally recognised that this applies only to an impeller having an infinite number of infinitely thin vanes, operating on a frictionless fluid. In practice, the introduction of friction modifies the uniformity of discharge very materially. The author's attention was drawn to this point by the result of an experiment designed to test whether, in fact, the fluid did utilise the full channel area provided.

The pump employed was fitted with an impeller of the built-up type, from which the shroud could be removed. The walls of the channels were coated with thick paint and, while the paint was still wet, the pump was run for 15 minutes at its normal output, with the unexpected result indicated in channel A, Fig. 1, herewith, which shows the flow markings left on the wet paint. It was not immediately obvious what series of currents had caused these markings, but eventually it was realised that the relative movements in the fluid passing through the channel would be the same as in pipe flow, where the velocity is a maximum at the centre and the fluid in contact with the walls is practically stationary; and that the markings indicated a "creep" from the region of high pressure along the leading edge of a vane, to the region of relatively low pressure along the trailing edge. The distribution of the radial velocity at exit, therefore, is approximately as shown in Fig. 4, on page 102, which is very different from the uniform velocity postulated by the theory. The real difference can be seen by studying the effect on the absolute volocity (Fig. 4), where it will be seen that the outer layers of the streams issuing from the impeller have absolute velocities nearly equal to the tip speed, while the corresponding velocity at the centre is very much less. This divergence from uniformity of discharge may have little effect in a volute-type pump; but when the impeller discharges into guide passages, where the velocity distribution is a maximum at the centre and a minimum at the walls, it might be worth while to consider making the guide passage wider in relation to the impeller than is the usual practice at present.

Fig. 1.



This experiment having failed to indicate the contour of what may be termed the effective stream, another series of tests was carried out, with the trailing edges of the vanes extended round the outer circumference so as to blank off varying percentages of the exit area, as shown by channel B in Fig. 1. The outputs given by the pump with the different openings are shown by the curves in Fig. 2, herewith. Test No. 1, with the smallest outlet, gave the characteristics of a choked pump, while No. 3 passed practically the same quantity as No. 5, with a higher efficiency, but with a lower head at the normal outputs. Neither did these tests provide the desired results, however, as there was nothing to prove that the effective stream did not utilise the full area during test No. 5; but it will be shown later that the effective streams were probably similar during both No. 3 and No. 5 tests.

The text-book theory deals only with the normal quantity, or that at which maximum efficiency occurs. This is regrettable, as some interesting points arise with outputs other than the normal; for instance, the form taken by the inlet diagram at an output of, say, 50 per cent. of the normal. This question has been asked on a number of occasions and the answer has always been represented by the triangle A D C in Fig. 3, on page 102; whereas the correct answer is represented by the triangle $AB_{0\cdot5}C$. From this it would appear that the general view is that the fluid flows through the impeller channels, yet the text-books indicate that the movement in the channels is relative. Correspondents discussing this point in ENGINEERING state that they have difficulty in seeing any difference between the conception of the fluid flowing in the channels and the vanes being driven through the absolute streams; but the difference shows itself in several ways: (*a*) it allows theorists to prove, by algebraic reasoning, that optimum pre-rotation would increase the quantity delivered by some 25 per cent., whereas actual test demonstrates that the head, quantity, and efficiency are reduced if pre-rotation is permitted; (*b*) it encourages some modern authors to advocate an allowance for pre-rotation up to as much as 50 per cent. of the tip speed, with the object of reducing the relative velocity, though unfortunately the additional area provided to pass the quantity at the reduced velocity is not utilised; (*c*) it has led one authority to stipulate that the maximum suction effect could be obtained only by limiting the relative velocity to 12 ft. per second, regardless of the tip speed; a rule which, if applied to inlet tip speeds above 15 ft. to 20 ft. per second, provides channels areas (as in (*b*), above) out of all proportion to the requirements; and (*d*) when other writers have allocated values to the various losses through the pump, the effect of the friction due to the wetted channels has been invariably treated as a hydraulic loss and deducted from the total head; whereas this frictional effect tends to increase the head.

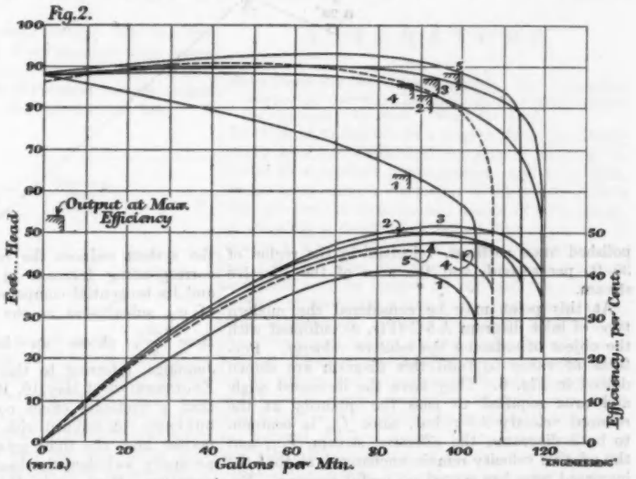
These instances of the results of converting a relative motion into a flow through the impeller channels can be traced to the theoretical assumption that the effective stream completely fills the channel and to the circumstance that, when an impeller drawing is studied, the picture is stationary. In what follows it must be understood that the term "stream," or "effective stream," refers to the area at any section or the volume of the channel occupied by the pump output divided by the number of vanes, and ignoring neck-ring leakage and eddy formations, if any; and that this stream flows along the lines marked "approximate path of absolute streams" in the direction of the arrows. Figs. 5, 6 and 7, on page 103, show some of the conditions obtaining in the channels for outputs of 50 per cent., 100 per cent., and 150 per cent. of the normal, respectively. The vanes and profile shown in Fig. 4 are those of an impeller which was tested in a single-inlet central-suction volute-type pump.

The leading dimensions and area are given, as it is intended to illustrate some points by results obtained on test. The diagrams to which the impeller was designed are not now available, and those shown in Fig. 3 have been based on the normal test output of 850 gals. per minute, and 96 ft. head at 1,460 r.p.m. To illustrate the type of inlet diagram that is associated with reduced outputs (say, 50 per cent. of normal quantity) by means of a simple arithmetical calculation, reference may be made to Fig. 5 and the fluid particle p_1, flowing along the stream line S L with the velocity $f_{0\cdot5}$ ft. per second. The radial distance $x_{0\cdot5}$ in. from d_1, which p_1 moves in the time t sec. taken by the vane tip T to reach the position T_1, is given by the expression

$$x_{0\cdot5} \text{ in.} = \frac{720 \cdot f_{0\cdot5}}{\text{r.p.m.} \times z},$$

z being the number of vanes. The same point is reached by plotting the relative positions of p_1 and the tip T for the same time, t sec., thus forming the involute curve marked 0·5. It will be seen that,

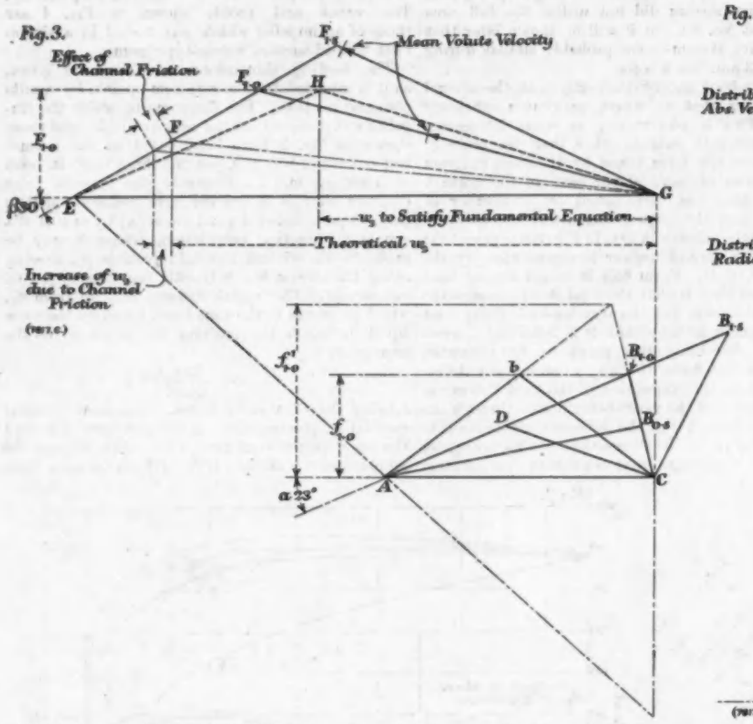
Fig. 2.



for the 50 per cent. quantity, the cross-sectional area of the effective stream is approximately half of the channel area provided, giving the inlet diagram A $B_{0\cdot5}$ C, Fig. 3, rather than the triangle A D C previously mentioned, and that the relative velocity varies little, up to the quantity that requires a cross-sectional area of effective stream just equal to the channel area. It also follows that the contour of the absolute streams varies little, up to the same quantity. Similarly, Fig. 6 shows $x_{1\cdot0}$ in. and the involute curve marked "1·0" for the 100 per cent. output; it will be noted that the channel area provided is not yet completely filled.

The involute curves of flow before entry into the channels represent what may be conveniently termed the "leading layer" of the effective stream. The contour of this layer after entry, as shown by the dotted lines, is problematical. Professor Gibson states that the relative velocity increases outwards; but it is not clear from the reference in his book whether the effect of channel friction had been considered or not. Assuming that it had, the leading layer would converge towards the vane, accelerating the stream in the directions of the arrows. Text-book theory, on the other hand, in order to fill the channel completely, would require the particle p_2 to take up positions along the chain-dotted line drawn from p_2 in Fig. 6. Is there any known force or source of energy to provide the acceleration or impulse needed to cause p_2 to diverge from the vane from which it derives its motion? The contour shown is based on the effect of the channel friction on the relative velocity. The friction, in turn, was calculated from $h_f = \frac{f l v^2}{2 g m}$, where $f = 0{\cdot}0038$, from a consideration of the

FLOW THROUGH CENTRIFUGAL PUMPS.



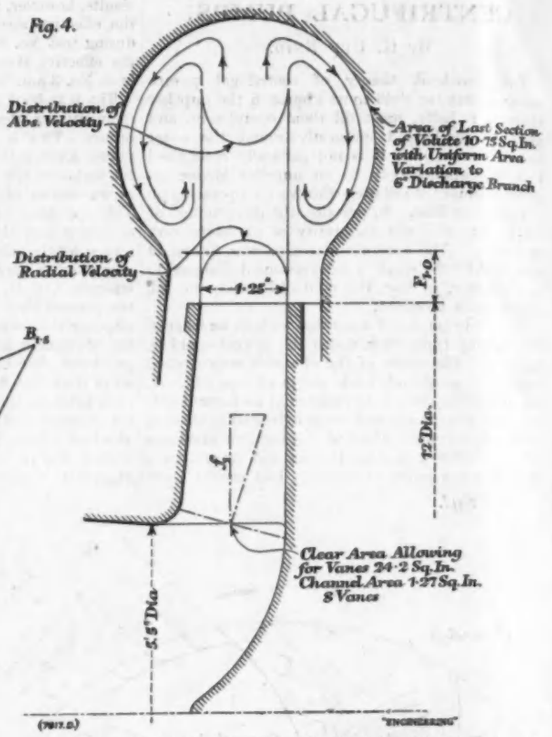


Fig. 4.
Distribution of Abs. Velocity
Area of Last Section of Volute 10·75 Sq.In. with Uniform Area Variation to 6" Discharge Branch
Distribution of Radial Velocity
1·25"
$F_{1\cdot0}$
12" Dia.
$f_{1\cdot0}$
Clear Area Allowing for Vanes 24·2 Sq.In. Channel Area 1·27 Sq.In. 8 Vanes
5·5" Dia.
(full c.)
"ENGINEERING"

polished brass surfaces, velocities in the region of 30 ft. per second, and the area of the effective stream.

At this point may be considered the modern type of inlet diagram A *b* C (Fig. 3), adopted with the object of reducing the relative velocity. Portions of vanes to fulfil this diagram are shown dotted in Fig. 6. They have the increased angle and area required to pass the quantity at the reduced velocity A *b*; but, since $f_{1\cdot0}$ is common to both diagrams, the effective stream, $x_{1\cdot0}$, and the relative velocity remain unchanged, so that the increased area has served no useful purpose. Regarding this increased angle, it was suggested by Mr. J. Jennings, in his letter published on April 4, 1941,* that "a steeper inlet angle may lead to a more favourable vane shape and certainly a shorter passage, and thus reduce overall losses despite shock at inlet." Later, on page 396 of the same volume, having accepted the condition that the relative velocity varies little until the effective stream occupies the full channel area provided, he gave diagrams to show that, once within the sphere of influence of the impeller, the steeper angle reduces the relative velocity. Unfortunately, he overlooked the fact that the steeper angle also increases $f_{1\cdot0}$ to $f'_{1\cdot0}$, and that, far from attaining the desired object, it actually increases the relative velocity, as can be seen by producing the lines A *b* and C $B_{1\cdot0}$ to meet at $f'_{1\cdot0}$. All this illustrates case (*b*), and goes to show how misleading it is to think of the fluid merely as flowing through the impeller channels. Fig. 7, for the 150 per cent. output, shows a very different set of conditions; the initial portions of the vanes are not absorbing energy, but are being reacted upon by the absolute streams. This is also indicated by the diagram A $B_{1\cdot5}$ C, Fig. 3. The leading layer of the stream is again fixed by the estimated effect of channel friction, *f* in this case having a value of 0·0034, as the average velocity is about 45 ft. per second.

The effect of the channel friction on the performance of the pump, case (*d*), can be shown by reference to the theoretical diagram E F G in Fig. 3. As already mentioned, this diagram refers to a frictionless fluid. The introduction of friction into the system reduces the relative velocity, with a corresponding increase in the absolute velocity and its tangential component w_2. This new value of w_2, substituted in the fundamental equation, $H = \frac{u_2 w_2}{g}$, shows an increase in head. Mr. Jennings, referring to this point on page 396 of ENGINEERING of May 16, 1941, and having realised that a frictional effect could increase the head, but being still imbued with the idea that it does not matter how the fluid gets through the impeller, promptly switches the loss from the head to the quantity. Here again this strange fantasy, like a will-o'-the-wisp, has led him astray, as it has done to so many others. In a pump of normal proportions the quantity is controlled by the depth of the effective stream over the vane tip at the inlet, for the fundamental reason that the volume passing this point must be discharged. The effect of channel friction is to reduce the relative velocity, or to increase the absolute velocity of the effective stream or its acceleration, whichever term is the more acceptable, and thereby to increase its cross-sectional area outwards.

Exit diagrams for the 100 per cent. and 150 per cent. outputs are given in Fig. 3, and are based on the cross-sectional areas of the respective effective streams. According to the modern theory of pump action, the mean direction of flow from the impeller does not correspond to the vane angle; it is illustrated by the triangle EHG. The value of w_2 from this diagram, substituted in $H = \frac{u_2 w_2}{g}$ and multiplied by a hydraulic efficiency of 87·8 per cent., gives the head generated at 100 per cent. of normal quantity. The corresponding mechanical and volumetric efficiencies are 93 per cent. and 98 per cent., respectively. It is doubtful, however, if this is the correct procedure to adopt. It is based on the fluid flowing in the channels and, if applied to the 150 per cent. output, would give an absolute velocity less than the mean volute velocity, so that the pump should not have been capable of the output actually recorded on test. It is more likely that the absolute velocity which gives a suitable value of w_2 occurs beyond the influence of the vane, its value falling between the actual $GF_{1\cdot0}$ and the mean volute velocity.

Text-books, when dealing with the conditions in the volute, refer to shock at entry; but can this effect occur? In fluids with a viscosity equal to that of water, the resistance to shear is negligible. An indicator of an admittedly crude type showed that the absolute stream leaving the impeller continues outwards until it reaches the surface of the volute. It divides into two streams which flow in right-hand and left-hand spiral paths round the volute, as shown in Fig. 4, on this page; therefore, the only losses appear to be due to eddy formation and skin friction. This complicated system of velocities, with the accompanying variation of pressure from the inner to the outer radius of the volute, is discharged into the diffuser or straight conical discharge passage. Two views can be taken of the conditions in the diffuser: it may be regarded either as a means of reducing the velocity gradually to that in the discharge branch, with an accompanying increase of pressure, or as the straight length following a bend. It should be remembered that the loss of head resulting from a bend in a pipe line does not occur so much in the bend itself as in the straight length following it; this is where the drop in pressure is found.

Mr. A. Maude, commenting on this point on page 395 of the previous volume of ENGINEERING, questioned "whether the whole of the carefully-shaped discharge passage is supposed to have zero efficiency?" This is a very difficult question to answer, but the following calculation may enable him and others to come to some decision upon it. Treating the diffuser as such, and taking the 100 per cent. output as an example, the possible increase in pressure, allowing a conversion efficiency of 90 per cent. from velocity to pressure, would be 11·3 ft.; but, treating the diffuser as a straight length of pipe, following a bend, and the loss due to a bend as $0{\cdot}8\,\frac{v_2}{2g}$, the loss would be 11·6 ft. In the following analysis, the volute pressure has been taken as equal to the delivery gauge pressure. When dealing with pumps that are fitted with guide vanes, consideration should be given to the difference between the theoretical discharge angle FGE and the actual angle $F_{1\cdot0}$ G E (Fig. 3). It would appear that at least the centre line of the guide passage should conform to the latter angle.

* See ENGINEERING, vol. 151, page 276 (1941).

FLOW THROUGH CENTRIFUGAL PUMPS.

Fig. 5.

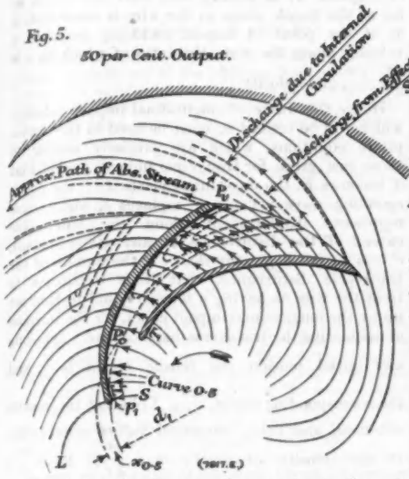

50 per Cent. Output.
Discharge due to Internal Circulation
Discharge from Effective Stream
Approx. Path of Abs. Stream
Curve 0·5
(TO FACE P. 104.)

Fig. 6.

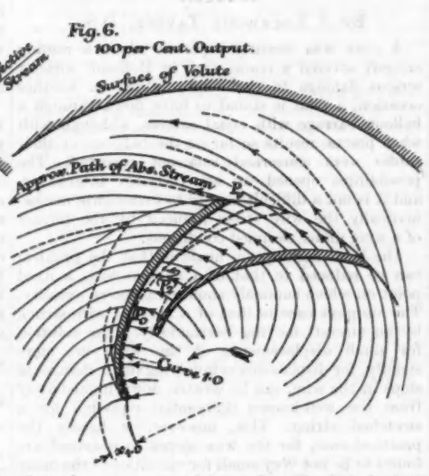
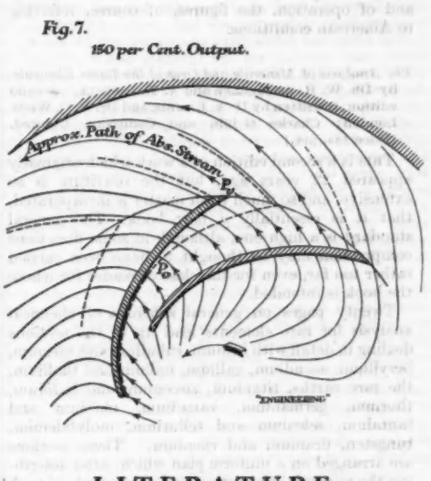


Fig. 7.



No attempt has been made to estimate the exit conditions at 50 per cent. of the normal quantity, as it is considered that this is complicated by internal circulation. Table I, herewith, gives the approximate pressures in the pump at the three outputs taken. For 50 per cent., the figures show that the pressure in the volute, P_v, which is 98 ft., is greater than the centrifugal pressure corresponding to the tip speed, namely, 91·5 ft.; and that the pressure difference acting inwards, between P_v and P_0, the approximate position of the lowest pressure in the system, is 104·9 ft. There can be little doubt, therefore, that the fluid will flow inwards along the trailing surface of the vane, as shown in Fig. 5. No corresponding estimate has been made of these conditions at 100 per cent. of the quantity, but the corresponding space in Fig. 7, at 150 per cent., can be safely assumed to be empty. The effective streams shown bear a resemblance to the flow in an instantaneous photograph given by J. A. Smith, of Melbourne, in ENGINEERING of December 5, 1902, showing a model impeller discharging into the atmosphere.

TABLE I.

Percentage of Normal Output.	G.P.M.	Ft. Hd.	R.P.M.	Efficiency Per Cent.	Suction Gauge Reading. P_s, Ft.	Estimated Loss P_2 to P_0, Ft.	Pressure at P_0, Ft.	Discharge Gauge Reading. Ft.	$P_v - P_0$, Ft.
50	425	104	1,475	64	− 6·0	− 0·9	− 6·9	98.0	104·9
100	850	96	1,460	80	− 10·0	− 3·5	− 13·5	86.0	99·5
150	1,275	46	1,455	42	− 16·5	− 7·9	− 24·4	29.5	53·9

It is suggested that, when a head-volume curve has a rising characteristic, some of the rise depends on the quantity of fluid in internal circulation. Referring again to Fig. 2, and taking about 50 per cent. of the normal quantity as an example, it will be seen that the internal circulation during test 5 will be much greater than in test 3; so that the quantity actually delivered by the impeller, and the power absorbed, will be greater. Some of this additional energy is returned in the form of a higher head, but, due to the relatively poor efficiency of the volute as a means of converting velocity into pressure, the overall efficiency will be less. This is borne out by the test results, as the efficiency during test 3 is higher than that of test 5.

The last note deals with the classification of impeller friction. Mr. Jennings, on page 122 of vol. 151, from a résumé of information collected from various sources, gave two classifications: (*a*), where the friction due to the total wetted surface of the impeller was treated as a hydraulic loss, and (*b*), where the friction of the outer surfaces of the shroud was regarded as mechanical and the remainder of the loss as hydraulic. A third classification has been put forward for consideration, on page 215 of vol. 151, suggesting that the total loss should be treated as mechanical, for the reason that the vanes are driven through the absolute streams, thus making the channel loss more mechanical than hydraulic. Mr. Jennings, criticising this view on page 396 of the same volume, asked for a simple definition of "mechanical loss." A parallel case from ship-model tank work may suffice. Various investigators of hull friction, from William Froude onwards, have towed planks through still water. The mechanical energy dissipated in such experiments is entirely lost in eddy formation and skin friction. The only difference between this experiment and the case under consideration is that the plank has been replaced by a bent vane, and the still water by a moving stream; the other features remain unchanged. What is required are simple definitions of the terms "velocity" and "relative velocity."

It is essential to remember that the vanes are moving through the absolute stream; there is no other view of the conditions that will conform to the text-book theory that the movement in the channels is relative. It might be worth while also to put the question (already described as rank heresy), does a centrifugal pump operate by centrifugal force? This is not an original query; it was put to the author, some 20 years ago, by Mr. J. R. Broadley, an engineer whose views on engineering problems were usually worthy of careful consideration. He suggested that atmospheric pressure, acting in the direction of the region of reduced pressure, P_0, provided a certain depth of fluid above the vane tip at inlet; and thereafter the vanes acting as wedges, forced the fluid or effective streams outwards into the volute. It is possible that Figs. 5, 6 and 7 present the picture as Mr. Broadley saw it.

THE "PRECALORIE" FUSION-WELDING PROCESS.—Messrs. Daniel Adamson and Company, Limited, Dukinfield, Cheshire, have developed a process for the manufacture of high-grade fusion-welded pressure vessels which, they claim, ensures consistent reliability and uniformity of test results in the finished vessel. The new method of manufacture has been given the name of Precalorie Process and, while no technical details regarding it are available for publication, it is stated to involve strict control of the temperature employed during the welding operation, whether this be carried out by manual or mechanical means. It is further stated that the possibility of the formation of gas crevices or pockets in the weld metal is avoided and that the fusion-welded product is free from other manufacturing defects.

LITERATURE.

Steam Power Stations. Second Edition. By PROFESSOR GUSTAF A. GAFFERT. London: McGraw-Hill Publishing Company, Limited. [Price 31*s.* 6*d.*]

To attempt to describe in a single volume practically every kind of mechanical equipment likely to be found in a modern power station, and to include, at the same time, a discussion of the considerations that govern the location and design of such plants, is certainly a formidable undertaking; yet this is the task which the author of the present treatise set himself. The measure of the success he has achieved may be judged by the call for a second edition of his work within three years or so of its first appearance. This is essentially a text-book for young men taking up the profession of power-station engineer, and anxious to know something of the nature and functions of the machinery they will have to control, but many of their seniors will also find it worth reading, particularly the chapters on general station design. The structural work and electrical equipment of stations are outside the scope of the treatise, but it is comprehensive enough otherwise to include chapters on fuels and combustion, feed-water treatment, etc., in addition to descriptions of the many kinds of apparatus involved in handling and burning coal, disposing of ashes and flue gases, and utilising the heat and steam produced.

Prime movers receive somewhat scanty treatment, as machines ranging from the simplest of slide-valve engines to the largest of turbines, together with a considerable amount of theory, are disposed of in less than 60 pages. The criticisms of the theoretical portion, which we felt compelled to make when reviewing the former edition, still hold good, however; and if it is still considered necessary to explain the well-known "P.L.A.N." formula for horse-power to a student who is assumed on the next page to understand entropy and the Mollier diagram, he should at least be told that N denotes the number of strokes of the engine, and not the revolutions per minute, as stated. He would also get the impression, almost certainly, that the first kind of turbine to be used in a power station was the vertical Curtis type, whereas this only came into existence after the Parsons turbine had been in use for something like twenty years.

The descriptive matter is clear and to the point, adequately illustrated, and can be read throughout with interest. No student could finish the book without having acquired a very fair knowledge, not only of the main machinery, but also of the great variety of auxiliary plant necessary to the operation of a large modern central station. The later chapters, on steam station costs, load curves and plant location, cycle arrangement, station design, etc., effectively bring out the broader aspects of central-station engineering, and especially the financial questions which young men are too often

apt to disregard in their enthusiasm for technical progress. These chapters are strengthened by many examples of actual costs, both of machinery and of operation, the figures, of course, referring to American conditions.

The Analysis of Minerals and Ores of the Rarer Elements. By Dr. W. R. Schoeller and A. R. Powell. Second edition, rewritten by D. A. Lambie and Dr. R. C. Wells. London: Charles Griffin and Company, Limited. [Price 18*s.* net.]

This is a second edition of a work which originally appeared 22 years ago, but the rewriting is so extensive, and so much fresh matter is incorporated, that it is essentially a new book. The general standard is a high one, although in some directions compression may be thought to have been carried rather too far, even for the class of reader for whom the book is intended.

Twenty pages on general schemes of chemical analysis for rare elements lead up to the sections dealing in detail with lithium, rubidium and caesium, beryllium, scandium, gallium, indium and thallium, the rare earths, titanium, zirconium and hafnium, thorium, germanium, vanadium, niobium and tantalum, selenium and tellurium, molybdenum, tungsten, uranium and rhenium. These sections are arranged on a uniform plan which, after describing the minerals, properties, and compounds of each metal and the principles involved in its determination in ores and metals, gives a scheme or schemes for the complete analysis of the ores. These sections vary in length, but the matter in each is well selected and concisely but adequately presented, so that, with the aid of cross references to other sections, most users of the book will find their normal requirements well covered. The sections on molybdenum and tungsten are by D. A. Lambie and that on rubidium and caesium by Dr. R. C. Wells. The section on niobium and tantalum is rightly based chiefly on the methods developed by the authors themselves and their collaborators during the past 20 years. The authors' claim that few methods are put forward of which they have no personal experience is amply supported by internal evidence. Judging by those sections which we are in a position to assess closely, the methods advocated are sound and well chosen. Modern reagents and principles are well exploited and there is a refreshing utilisation of methods other than the purely chemical. In some sections, concerning elements commonly found in industrial metals and alloys, a certain amount of information is given regarding the analysis of such alloys for the element concerned, but this is not done consistently; in particular, the consideration of steel analysis is often omitted or is incomplete, and since the work has a sub-title "A Manual for Analytical Chemists, Metallurgists and Advanced Students," this feature may occasion disappointment to metallurgists who are primarily concerned with the metals themselves rather than the extraction or ore-dressing processes.

The platinum group of metals is catered for in a section which is necessarily planned on different lines from those of the previous sections, since the estimation of its members is based on dry assay. The authors' claim that this section is the most up-to-date guide to the analysis of this group is thoroughly justified. The same skill in concise but adequate presentation shown in earlier sections, has enabled a remarkably complete account to be given of the determination of osmium, ruthenium, rhodium, iridium, platinum and palladium. Quite understandably, the practice of general fire assaying is covered only in bare outline.

As previously suggested, however, the tendency to compression is sometimes carried rather too far. For example, the introductory section of the book, dealing with manipulative techniques, is hardly more than a series of generally excellent hints; and it is doubtful whether the omission of all reference to the importance of sampling is justified. The sub-section on filter pulp does not do justice to the possibilities of this medium, and a reference to the Rothé ether separation might well have been included. The very welcome section on mineralogical analysis, as opposed to chemical analysis, might have been expanded with advantage.

IMPACT ON A STRETCHED WIRE.

By J. Lockwood Taylor, D.Sc.

A case was recently reported where a raiding aircraft severed a crane wire, in Holland, without serious damage to the wing; while, on another occasion, a pilot is stated to have flown through a balloon barrage with equal success, although with what precise results so far as the balloons or their cables were concerned was not reported. The possibilities opened up are certainly interesting, and it is not a difficult matter to investigate mathematically the wire stress induced by the impact of a wing under assumed conditions.

The basic assumption made is that the problem can be reduced to that of a flexible wire, a fixed point on which suddenly acquires a known velocity. The simplest case is that of a vertical wire struck by an aircraft moving horizontally. The solution for small displacements of the wire, or, more strictly, for displacements involving small changes of slope in the wire, can be written down immediately from the well-known differential equation for a stretched string. This, however, is hardly the practical case, for the wire slopes so obtained are found to be not very small for velocities of the order in question. The finite wire slope introduces a secondary effect, namely, a further stretch in the wire over and above that corresponding with the initial tension. The value of the excess induced

tension can be estimated, and proves to be large compared with probable values of the initial tension, and to extend over a length of wire which is large compared with that subject to transverse displacement at any given instant. Using this value of the induced tension in the stretched-string equations, therefore, is legitimate, and gives the desired solution, incidentally reducing the calculated wire slope to a more moderate value.

The basic differential equation is—

$$\frac{m}{g}\frac{d^2y}{dt^2} = T\frac{d^2y}{dx^2}$$

where m is the density of the material, T the tensile stress in the wire, and y represents the transverse displacement at a distance x from the point of impact. The appropriate solution is

$$y = \frac{v}{c}(c\,t - x),$$

holding for positive values of $(c\,t - x)$; y being zero for other values, *i.e.*, for $x > c\,t$; t being reckoned from the instant of impact. The speed of travel of transverse vibrations, c, is equal to $\sqrt{T\frac{g}{m}}$, and v is the velocity of impact. The kinked form of displacement represented by the equation is shown in the accompanying sketch.

As already explained, the appropriate value of the tension T, and hence of c, is to be found by considering the stretch in the wire due to the transverse displacement, the total length, including the kinked portion of the wire, being increased by the amount $\sqrt{1+\frac{v^2}{c^2}} - 1$, or $\frac{v^2}{2c^2}$ nearly, for small and moderate values of the slope $\frac{v}{c}$, considering, for simplicity, the instant when the kink has travelled unit distance along the wire. This extension applies to either half of the wire, above and below the point of impact. It is readily seen that the effect, so far as the tensile stress in the wire is concerned, is as if the point of impact suddenly acquired a velocity along the wire, the ratio of which to v is $\frac{v^2}{2c^2} \div \frac{v}{c}$, or a velocity $\frac{v^2}{2c}$.

Hence this value of longitudinal impact velocity, which will be termed u, must be used in the appropriate equations, which are precisely similar to those just given for transverse impact, except that T becomes E, the modulus of elasticity; the corresponding wave velocity c' replaces c, and y now represents displacement along the wire. The extent of the disturbance at any given instant, $c'\,t$, is so much greater than $c\,t$, the extent of the transverse disturbance, that it is legitimate to treat the wire as having a tension equal to that set up by the longitudinal impact effect, for the purpose of calculating the transverse displacement. Ignoring any initial tension, the tensile strain is $\frac{u}{c'}$, and the corresponding stress, $\frac{E\,u}{c'}$. Collating the results obtained, and using numerical values appropriate to the density of steel: $u = \frac{v^2}{2\,c}$; $T = \frac{E\,v}{c'}$; $c^2 = 9{\cdot}6\,T$; and $c'^2 = 9{\cdot}6\,E$. (T, E is in lb. per square inch.) Elimination gives $u^2 = \frac{v^4}{4\,c'^2}$, or $\frac{u^2}{c'^2} = \frac{v^4}{4c'^4}$. As a numerical example, taking v as 400 ft. per second, and c' as 15,000 ft. per second ($E = 23 \times 10^6$ lb. per square inch, for stranded wire) gives $u = 75$ ft. per second, and $T = 50$ tons per square inch, approximately.

The effect of a departure of the wire from the vertical in the direction of flight, or of an inclination of the path of the aircraft to the horizontal, is to increase the effective value of u in terms of v and c for either the upper or lower half of the wire by an amount v multiplied by the angle in question, provided there is no slipping at the point of impact. The final result of including this in the equations is to increase u by a somewhat smaller amount, since c is also increased, due to the increase in T, the tension.

TIN IN GLASS MANUFACTURE.

Although tin is not one of the main constituents of glasses, it is widely employed in small amounts to modify colour and transparency and also to produce certain finishes on glassware. It is stated in the current quarterly review, *Tin and its Uses*, issued by the Tin Research Institute, Fraser-road, Greenford, Middlesex, that the dense whiteness of stannic oxide, and its low solubility in glass, renders it one of the best opacifiers known to glass makers. Moreover, for centuries it was the only opacifying agent available. In modern times opal glass shades for oil and gas lamps have been made by putting a thin tin-opal glass "flash" casing on to clear glass, and, subsequently, similar methods were employed for electric-lamp shades. In recent years, however, the opacifying agents employed for these and similar purposes have been low-cost substitutes such as fluorides. In this connection the author of the article points out that it is open to question whether these substitutes are cheaper in the long run, when the more rapid erosion of the melting pots by the fluorides is taken into account.

Tin oxide continues to be used almost exclusively in the opal-glass backing of tubing intended for thermometers, burettes, levels, gauge glasses, and similar apparatus. Three reasons are given for this: in the first place the great density obtainable allows a very thin opal "flash" to be used; secondly, tin opals are considerably tougher than the substitutes available; and, thirdly, the opalescence is more stable during the melting and working operations. Another use for stannic oxide, in the manufacture of glassware, is as an abrasive for polishing the rough surface of cuts produced by carborundum wheels in the production of cut table glass. Under the name of "putty powder" the material is suspended in water and fed on to the edge of a wooden polishing wheel shaped to the angle of the cut. Stannous chloride is used in connection with the production of ruby glasses which derive their colour from colloidal gold or, more commonly, copper. Another salt of tin, stannic chloride, is used to obtain an iridescent effect on decorative glassware by exposing the finished articles to the vapour of the salt in a kiln.

RESEARCH IN CANADA.*

By LIEUT.-GENERAL A. G. L. McNAUGHTON, C.B., C.M.G., D.S.O.

(*Concluded from page* 65.)

Encouragement of Research in Universities, etc.—In order to make use of the facilities for research which exist in a number of our Canadian universities and to encourage their further development, the Council, in the early years of its existence, instituted a system of assisted researches through which the professors in charge could be given financial assistance for the provision of needed apparatus, laboratory help and similar out-of-pocket expenses, other than their own salaries. Applications for such assistance are most sympathetically considered and by its aid much useful work has been accomplished, of value both for the new knowledge secured and, perhaps even more important, for the training given to the workers. Another aspect of the Council's concern with the training of research workers is represented by the scholarships which each year are awarded to some 70 or more post-graduate students. These are tenable at Canadian universities or, in special cases, abroad. Though these scholarships, which are being given year by year in increasing numbers, in addition to providing the needed supply of highly trained research workers, a deliberate attempt has been made to assist the building up of the post-graduate schools in the Canadian universities.

From what I have said about associate committees, assisted research and scholarships, I hope I have made it clear that while the Council has itself a number of very well-equipped laboratories in all lines, yet there has been no attempt to monopolise research; in fact, the very opposite, for it has long been realised that for the safety of the nation against peace-time industrial competition, let alone to meet the needs in war, you can never have too much research. In Canada the difficulties are particularly acute for, as is well known, most of our principal industrial companies have affiliations with larger organisations abroad to whom there has been a natural tendency to refer any research problems that arise from time to time. It is often very difficult to examine these problems completely, apart from the special environment in which they have come to attention. The solutions proposed are often, therefore, inadequate, and, both on this ground and on account of delays, very heavy losses are involved. A more serious loss is due to the fact that without a corps of trained investigators on the spot, the needs of the situation are not fully appreciated, and many opportunities for useful inventions and developments are missed or unduly delayed.

Research Information and International Affiliations.—In peace, in order to maintain our contact with research work going on all over the world, the Council maintains membership in the principal International Scientific Conferences and meetings, arranges for Canadian representation where required, and collects in its library in Ottawa, for reference, copies of all papers, proceedings and other information of importance. This is made available as desired to Canadian workers. For many years also the Council has maintained the closest possible contacts with the Department of Scientific and Industrial Research and the British Standards Institution here. These contacts were strengthened and developed by the Imperial Conference of 1930 and the Imperial Scientific Conference of 1936, and again in August, 1939, on the occasion of the visit to England of a representative group of Canadian manufacturers, who had come to England to familiarise themselves with the needs of war-time industry, so that Canadian production could be directed to those articles which would be most required and most useful.

War-Time Developments.—I have endeavoured to give you a brief picture of the origin and growth of the National Research Council up to the outbreak of the war in which we are now engaged. Relatively satisfactory as the situation had become when compared with 1914, I have not claimed that we had in Canada anything which was in any sense an adequate answer to the problems of competitive industry in peace, and certainly, as regards war, we scarcely dare, in the years of the ascendency of the Geneva school of thought, to admit that some of the research work in hand might even have an indirect value for defence. Apart from meeting the problems of the day as they presented themselves, what had been aimed at was the creation of a nucleus round which the research resources of the nation could be crystallised in order so soon as the real needs were recognised by public opinion and Parliamentary support was forthcoming. That such a nucleus was in fact created will, I think, be evident from what now I have to tell you with reference to the war-time developments of research in Canada. In this I am under the difficulty that no specific information which would be of value to the enemy can be disclosed, so I have to content myself with a few illustrative statements which must be rather general in character.

First, as regards finance. The funds placed at the disposal of the Council for the current year by votes from Parliament and grants-in-aid from the Naval, Land and Air Forces in the Department of National Defence are some five-fold greater than for the last pre-war year. In addition, the Council and its technical staff will be responsible for the scientific and technical organisation and advice in connection with other projects not directly administered, which will involve about twice to three times as much again. Further, in order to provide some measure of elasticity in the finances of the Council a number of Canadian corporations, large and small, and private individuals have joined together to establish a trust fund of well over a million dollars, with more available if required. The committee in charge has been enjoined by the donors to make it their business to ensure that no worthwhile project of research, related to the war effort of Canada, which is sponsored by the National Research Council, should be delayed or hampered by lack of money. In this public-spirited group the mining industries of Canada have, as usual, been conspicuous for their generous support of research. Another example of the assistance received from this source is the support given to the Canadian Corps in the organisation and equipment of our Tunnelling Companies. One of these, as is well known, is now at Gibraltar making effective use of the modern machinery presented by the Canadian mining industry. The other Company is using similar equipment in this country.

What is, in effect, a further additional expansion of the Council's activities is represented by Research Enterprises, Limited, a wholly owned Government corporation which has been set up by the Canadian Ministry of Supply primarily to produce for the armed Forces, and for industry, inventions and apparatus which had been developed in the Council's laboratories. Already, optical instruments, including gun sights and range finders, radio gear and similar articles, are in production in the large new factory which has been erected, and very shortly the company will be turning out its own supplies of optical glass in quantity. Thus a small nucleus established in the optical and radio laboratories in the years before the war has been given substance and developed into a key industry of essential importance for our war effort. The Council's metrology laboratories are another example of a small but effective nucleus which has been expanded to large dimensions to care for the standardisation of the vast number of gauges necessary in the munitions industry.

In the field of radiology, special attention has been paid in the Council's laboratories for many years to the examination of castings, particularly those in light alloys required to carry stress in aircraft construction. Working with the producers, the technique of making sound castings had been developed before the war to a high degree of perfection, and the knowledge of this art is now proving of great value to the Canadian aircraft industry. X-ray photographs can be taken at up to 600 kV, which is sufficient to penetrate several inches of steel. For greater thicknesses a plentiful supply of radium is available by reason of the fact that the bulk of the world's new supply derived from the mines at Great Bear Lake and refined by the Eldorado Company at their Port Hope Plant comes to the Council for test and certification. Turning to another of many fields, I should like to mention the very important programme which has been initiated by the Committee on Aviation Medicine under the chairmanship of the late Sir Frederick Banting.

In conclusion, I wish to assure you that all this great range of work of which I have been speaking is going forward in Canada in the closest sympathy and understanding, both with the authorities here and also with our mutual friends and colleagues in the United States. In order to help in the maintenance of effective contact the British Government have established a Scientific Liaison Office with the Council in Ottawa, and we have been privileged to receive first, Professor Fowler, and more recently, Sir Lawrence Bragg. At the present time a number of the senior members of the Council are in England to familiarise themselves with the latest methods and requirements so that our work may be kept related to problems of immediate practical importance. There is a constant flow and interchange of workers and the various problems are taken up as available facilities best indicate. Needless to say, there is no delay or reservation in making the results available for application and use.

* Paper read before the Royal Society of Arts on April 13, 1941. Abridged.

NICKEL-ALLOY WATER COOLING TUBING.—Tubing of the nickel-chromium-iron alloy Inconel is being employed for the water cooling of the carbon electrode holders on certain electric furnaces. It is found to be much more durable than steel tubing.

THE BRENTWOOD RAILWAY ACCIDENT.

AT 10.46 a.m. on Monday, February 10, 1941, the 10.0 a.m. express passenger train from Liverpool-street to Norwich, which had stopped owing to shortage of steam on the Brentwood bank about two miles east of Harold Wood station, on the London and North Eastern Railway, was run into from the rear at about 30 miles an hour by a stopping train from Liverpool-street to Southend, which had passed the preceding automatic colour-light signal at danger. Five passengers were killed outright and two more subsequently died from their injuries. Seventeen passengers, and the driver and fireman of the Southend train, were taken to hospital with serious injuries, and a further 20 passengers suffered minor injuries or shock. An inquiry into the circumstances was held by Major G. R. S. Wilson, R.E., of the Ministry of War Transport, the main points and the conclusion of whose report are summarised below.

The Norwich train comprised 13 bogie coaches, of modern construction, with heavy steel underframes, and was hauled by engine No. 2828, a 4-6-0 of the L.N.E.R. company's B.17 type, weighing 116 tons with the tender, in working order. The train weighed 414¼ tons, and was 274 yards long—a point of some significance, as it transpired, because of the time taken by the guard to walk forward to the engine, in accordance with the rule, to ascertain the cause of the unexpected stoppage. The Southend train consisted of ten non-corridor bogie coaches of older type, weighing 257 tons, and was hauled by engine No. 8556, a smaller 4-6-0 of the B.12 class, which weighed 108 tons in working order, including the tender. At the place where the collision occurred, about halfway up the 1 in 100 bank from Harold Wood to Brentwood, the line runs approximately from west to east and there are four tracks. These, in order from north to south, are the down local, up local, down through and up through. Colour-light signalling is fitted, and there are signalboxes at Gidea Park, 1½ miles west of Harold Wood, and at Brentwood, controlling the station signals. The intervening section is subdivided by a series of automatic signals, track-circuit controlled, and each provided with a telephone to one or the other of the two signal boxes. Both trains were running on the down through line.

The Norwich train had lost some time, as the engine was steaming badly and, before the Brentwood bank was reached, the steam pressure had fallen from 200 lb. to 160 lb. per square inch. The water was also low in the boiler, and Driver H. G. Hudson decided to stop, and to ask the Brentwood signalman for assistance. As only a small engine was available there, however, they agreed that he should wait until the normal boiler pressure was recovered. Signalman Fenton, at Brentwood, informed the train control office and Gidea Park box of this arrangement, but it was then too late to divert the Southend train to the up local line, as it had already passed Gidea Park. Adams, the head guard of the Norwich train, who was travelling in the eighth coach of the train, went forward to the engine, reaching it just as the driver finished telephoning. He then went back to protect the train, together with the assistant guard, who was in the ninth vehicle. They were near the rear of the train when they saw the Southend train approaching, and had only time to place one detonator, about 30 yards in the rear of their own train.

After the collision, the regulator on the engine of the Southend train was found to be half open and the handle of the vacuum ejector (operating the train brakes) was in the running position, though the driver had applied the Westinghouse brake with which the engine was fitted. The driver, F. C. Burkett, and the fireman, W. G. Porter, of the Southend train, both received severe burns and scalds, and three months elapsed before they were fit to give evidence. By that time, Burkett's recollection of his turn of duty on the morning was vague, but he remembered that the Harold Wood starting signal and the next signal after it were showing green when he passed them. Thereafter he remembered nothing until he saw the Norwich train "a yard or two ahead," and was quite unable to account for the fact that he had missed the next two signals, the first of which was at yellow and the second at red. He fully admitted his responsibility for the collision, and put forward no excuses or possibly extenuating circumstances. Fireman Porter, however, stated that, on one or two previous occasions, he had noticed Burkett become drowsy on the footplate, though only momentarily; and, in consequence, he had been more than ordinarily careful to look out for signals when his other duties permitted. On this occasion, with the engine working hard on a severe gradient, he was fully occupied with his fire.

Major Wilson, in his report, concluded that there was no doubt that the accident resulted from Burkett's failure to keep a proper look-out; and that, after

setting the engine controls for the ascent of the gradient, after leaving Harold Wood, he had relaxed his attention to such an extent that he became drowsy, and even might have fallen asleep on his seat. His own account indicated that he must have remained in this condition for about 2½ minutes. Such a grave lapse on the part of an experienced main-line driver, Major Wilson continued, was difficult to explain; Burkett was apparently in sound health, and had every opportunity for rest before taking his turn of duty, which was not exacting. No blame rested with the fireman. The accident might have been averted if the assistant guard had gone to the rear of the train while the head guard went forward, though the rules did not specifically require him to do this. Major Wilson stated, in conclusion, that he had no recommendation to make. Automatic train control would have prevented the collision but the arguments for its provision were not strong, on a main line with multi-aspect colour-light signalling. The accident was a reminder that, when a train stopped from any unusual cause, protective duties should be carried out promptly, even if the possibility of a signalman's error had been eliminated by track-circuiting.

AIR AND GAS PURIFICATION.

The plants illustrated in Figs. 1 to 5, on this and the opposite pages, are examples of the Traughber froth-flotation filter for the purification of dust-laden air and gases. The manufacture of these plants has been recently commenced by Messrs. Controlled Heat and Air, Limited, Cornwall-road, Smethwick, Birmingham, this firm being the licensees for the British Isles. The Traughber filter, as its full name implies, is a modern form of wet filter, the dust being separated from the air or gas containing it by first passing through a mist of liquid and then bubbling in fine streams through a layer of water charged with a small amount of oil having a very low surface tension. The mechanism by which the purification is effected is, naturally, enclosed in a casing or chamber, so that the external view, Fig. 1, is not particularly informative. It gives some idea, however, of the scale on which the filter is applied, the example illustrated being designed to purify 30,000 cub. ft. per minute of heavily dust-laden air drawn from machines used in the manufacture of abrasive grinding wheels. The principles and general construction of the filter will be clear from the drawings of Figs. 2 to 5, which show a smaller plant, designed to purify 10,000 cub. ft. of air or gas per minute.

The dust-laden air or gas enters the lower part of the filter casing through the branch *a*. This part, therefore, forms a receiver and below it is a base which forms a reservoir for the washing liquid and acts as a sump for the collected sludge. Overflow pipes, *b*, also visible in Fig. 1, keep the liquid level in the base constant, the settling tank into which these discharge providing the re-circulating supply. The sludge from the reservoir can be removed either periodically by hand or continuously by means of some form of conveyor. From the inclination of the branch *a*, it will be realised that the gases are directed downwards towards the surface of the liquid in the reservoir, the momentum of the coarser dust particles carrying them into the liquid while the finer particles still remain in suspension in the gases. These are then caused to pass through a mist of the liquid derived from the rotor *c*, through which mist they are deflected by the baffle *d*. The rotor is a smoothly-finished steel cylinder, running at about 1,200 r.p.m. Its underside just touches the surface of the liquid in a trough below it, so that the liquid is picked up and then discharged by centrifugal force in a fan-shaped mist of uniform density. After passing through this mist screen, the gases are directed by means of the baffle *e*, through a second mist screen derived from the rotor *f*. This rotor is similar in all respects to the rotor *c*.

The gases then pass upwards through the froth floor *g*. This, as shown in Fig. 2, consists of a number of narrow troughs, each covered by a U-shaped hood, with serrated edges, into which the gases enter. Since the edges of the hoods dip below the surface of the washing liquid contained in the troughs, which surface is covered with a film of special oil, the gases must bubble through the liquid in their upward passage. The result of this bubbling is the formation of a froth which constitutes a very effective filtering medium for trapping the finest particles of the dust. The dust-laden froth is automatically removed by overflow to the washing liquid reservoir below, the rate of escape being adjustable so that the thickness of the froth layer can be regulated to suit the conditions desired. The cleaned gases then pass upwards through a two-layered eliminator *h*, which retains any moisture particles or froth which might be entrained in them. The intercepted material returns to the washing liquid reservoir. The eliminators are filled with labyrinth rings. The liquid in the froth floor is renewed with fresh washing liquid from the tank in just sufficient quantity to float off the impurities entrapped in the froth. This flow is derived from a centrifugal circulating pump *i* drawing from the tank. The special oil is contained in a small tank *j*, Fig. 4, fitted with an adjustable sight-feed device by means of which the correct percentage of oil to washing liquid is maintained; a few drops falling into the liquid at intervals are generally sufficient.

So far nothing has been said about the means by which the air or gases are caused to pass through the filter. This is effected by an induced-draught fan the suction side of which is connected, as may be convenient, to the outlets *k* at the top of the filter casing. This induced draught possesses the advantage that the fan handles clean air or gas only, while, should any leak develop in the connecting pipes, only clean air would be drawn in. The size of fan necessarily depends on the volume of air or gas handled by the filter, and in this connection it may be mentioned that the static resistance of the filter is low. The same correlation exists with regard to the circulating pump, while the rotors, which, as is evident in Fig. 3, are driven by individual motors, require very little power since their surface contact with, and not deep immersion in, the washing liquid, causes very little resistance to rotation and they are mounted in ball bearings. Generally, motors of between 1 h.p. and 2 h.p. are sufficient. For each foot of length each rotor will convert 1,800 gall. of liquid into mist per hour. The size of the rotors is suited to the gases being dealt with, the character, density and size of the mist droplets being determined by the diameter of the rotor, its speed of rotation, and its closeness of contact with the liquid surface. As regards the latter, if large droplets are required, a slight immersion of the rotor in the liquid is necessary.

The physical principle underlying the operation of the filter may be indicated by pointing out that very fine particles suspended in air or other gases have a relatively large absorbed coating of air or gas and carry an electrostatic charge. The adsorbed film is sufficient to alter the density of the particle so that fine dust cannot overcome the surface tension of pure water on which it may be dropped; in other words, the particles cannot become wetted. But if the characteristics of the water are modified by the addition of an oil having a very low surface tension and if, moreover, the liquid thus formed is discharged at a high speed and in such proportions that a mist, as opposed to what is known as a spray, is produced, then the dust particles can be wetted and are thus made sufficiently tractable to be arrested by impingement either on a solid surface or to sink below the surface of the liquid in the reservoir. The droplets of the mist, or those constituting the froth, are all covered by a layer, infinitesimally thin, of the low surface-tension oil. It is stated that the oil-treated liquid retards evaporation and that the mist reduces the temperature of the incoming gas, with, in consequence, a reduction of its volume and velocity, condensation upon the particles being greatly accelerated. It is also claimed that the oil insulates the wetted particles electrically.

In connection with the reduction of volume, it will be clear from Fig. 2, that there are, in effect, two mist chambers. These, arranged in series, are the chamber below baffle *d*, and extending between baffles *d* and *e*; and the chamber above baffle *e*, the volume of the two chambers being successively larger. The gas contracting as it is cooled down by the mist, in combination with the increasing volume of the chambers, must, therefore, decrease in velocity. The smallest suspended particles, though effectively wetted, might not, if the conditions remained unaltered, settle by themselves, but having, by reason of their reduced velocity, more time for further condensations of moisture to take place on them, become heavier and can therefore settle more readily. The final stage, viz., that of bubbling the gases through froth, is not dependent on any change of velocity, the froth, in effect, acting as a constantly self-cleaning filter cloth of adjustable texture and resistance. The washing liquid, *i.e.*, the oil-treated water, after having the sludge removed in the receiving base, as already described, is further clarified in the settling tank, in

TRAUGHBER FROTH-FLOTATION FILTER.

MESSRS. CONTROLLED HEAT AND AIR, LIMITED, SMETHWICK.

Fig. 1.

TRAUGHBER FROTH-FLOTATION FILTER.

MESSRS. CONTROLLED HEAT AND AIR, LIMITED, SMETHWICK.

Fig. 2.

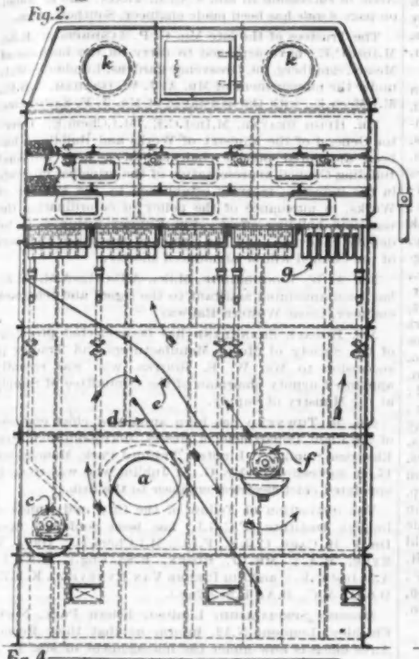


Fig. 3.

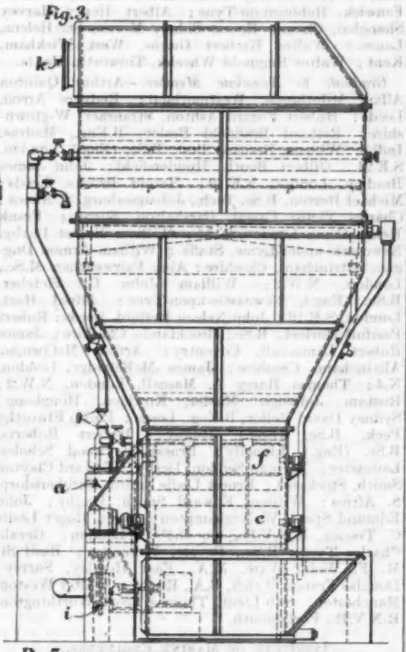


Fig. 4.

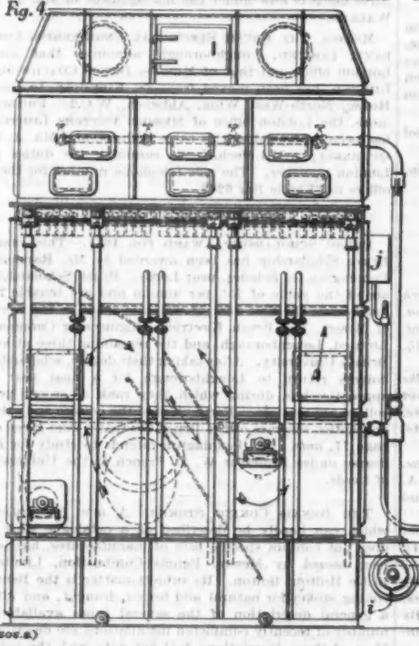
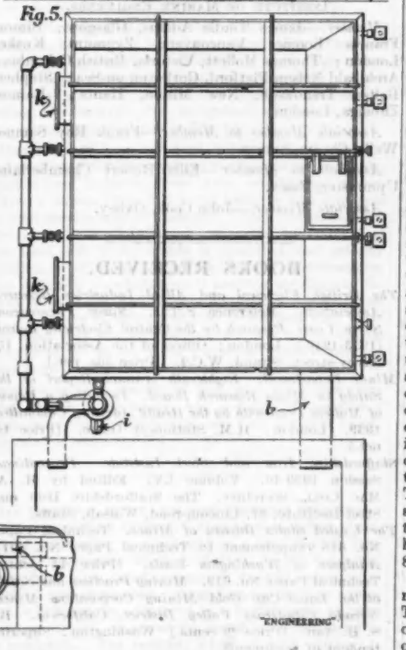


Fig. 5.



(1606.a)

which it becomes sufficiently clean to be recirculated. Any additional water is, therefore, only that required to make up for natural evaporation in the sludge trough and the settling tank. The oil consumption depends upon both the quantity of dust contained in the air to be treated and the nature of the dust; thus, dust consisting mostly of silica particles requires less oil than dust containing large proportions of carbon. The general construction of the filter, the disposition of the auxiliaries, pipes and so forth, and the position of the several air-tight cleaning doors in the casing, are so clearly indicated in Figs. 2 to 5 that comment on them is hardly necessary.

The Traughber froth-flotation filter can be employed for treating hot gases from industrial processes, as well as for removing dust from the atmosphere of workshops, etc. The filter illustrated in Fig. 1 is used for this latter purpose. But some atmospheres, such as those in foundries, are also contaminated by gases. Such of these gases as are soluble are readily removed as the oil-treated water is a more powerful solvent than pure water. This enables the filter, in many instances, to purify and deodorise the atmosphere concerned, the oil being an efficient disinfectant. Air thus cleaned can, therefore, be returned to the workshop from which it was drawn, a process which will probably result, in winter, in a saving of fuel in the shop heating plant. Where hot gases are to be treated, the filter has proved equally, if not more, efficient. It has, for example, given very satisfactory results in the recovery of lead oxides and zinc oxides from the fumes of smelting furnaces; in the purification of producer gases, often containing much dust; the absorption of H_2S and SO_2; the recovery of CS_2; and the recovery of silver and other valuable dusts. In such applications as the absorption of gases, the washing liquid naturally requires modification so that the substance it is desired to separate can be combined with others in such a form that it can be recovered; for example, carbon disulphide can be condensed and then distilled from the washing liquid. There is little loss either of the special oil or the washing liquid in dust-removing operations with hot gases.

Apart from known applications, such as those indicated above, together with the removal of dust from blast-furnace gases and boiler-flue gases, from cement-making plant, sand-blasting plant, and the like, it would appear that the filter offers possibilities in the purification of gases in which one constituent is a true gas at one temperature but contains suspended particles at another temperature. Examples are the tar fog in producer gas, and the fumes from certain metallurgical processes in which some of the metal vaporises into a gas at a given temperature and shows no tendency to separate out into particles in suspension until it is oxidised on contact with air. It is claimed for the Traughber filter that its efficiency is the highest yet reached and that both initial and maintenance costs are lower than those of any comparable plant, while less floor space is required and it can be situated in the open. It is also stated to be noiseless in operation and to need very little attention after proper initial adjustment; also there is no risk of fire.

100,000-KVA HYDRO-ELECTRIC GENERATOR FOR MANCHUKUO.

THE *Zeitschrift des Vereines Deutscher Ingenieure* for June 7, 1941, contains an article by Dipl.-Ing. H. Winkelsträter describing a 100,000-kVA hydro-electric alternator, which is said to be the largest yet constructed in Europe, both as regards output and dimensions. It has been built by the Siemens-Schuckert and Company, and is one of seven which are to be installed in a station on the Yalu River, on the frontier between Manchukuo and Korea. The output of 100,000 kVA is supplied at a pressure of 16,500 volts and a power factor of 0·9. The frequency of some of the machines is 50 and of others 60 cycles per second. The working and critical speeds are 150 r.p.m. and 298 r.p.m., respectively. The weight on the thrust bearing, including the rotor, turbine runner and water pressure, is 1,140 tons. The external diameter of the alternator is about 10 m., and its height above the floor of the turbine room is 8·8 m. The diameter and length of the machine were determined by the condition that the peripheral speed should not exceed 125 m. per second. The external diameter of the stator is 9,800 mm., and it is more than 3,100 mm. high.

Owing to transport restrictions it was necessary to divide the stator into six parts, which were welded together on site. To prevent distortion and to reduce fitting to a minimum, the joint straps of each part were connected to a column and each pair of columns was bolted together. Each pair of columns supports a plate on which the upper rotor spider is carried. The stator housing was also dispatched in sections and was connected to the columns by welding, as were the radial transverse members. Special measuring devices were used to secure exact alignment and to eliminate any stresses that might have been set up by welding, this operation being carried out simultaneously at a number of places in accordance with a detailed plan. Accuracy of the internal face of the housing, to which the stampings are fixed, was ensured by the use of packing pieces on the radial ribs, and these were carefully adjusted so that their distance from the axis was within —0·2 mm. These distance pieces were welded to the ribs, any serious inaccuracies being removed by grinding. In this way the variation in the internal diameter of the housing was limited to 0·2 mm. with an opening of 8,500 mm.

The stator laminations are built up of 110,000 segments, each 0·5 mm. thick, and insulated on one side. The slots and holes in each segment were stamped in one operation and the assembly was effected in bundles of 50, laid so that they were free to expand tangentially. This eliminated any radial expansion of the ring which, otherwise, would have amounted to 2 mm. in one direction with a temperature difference of 40 deg. C. Axially, each bundle of laminations is bolted to the housing, the pressure being transmitted through fingers of non-magnetic steel which are welded to plates. These plates are arranged with great accuracy so that they rest on the teeth between the slots. An equal spacing of the winding and fingers is thus obtained, a point which is considered to be of importance owing to the high voltage. The total height of the stampings assembly is 2,350 mm. and accurate alignment of the slots was secured by driving in packing pieces. The core is ventilated by 39 axial ducts, which are arranged vertically in such a way that the thickness of the individual bundles of stampings between adjacent air ducts varies from about 70 mm. at the ends to 40 mm. at the centre. The whole of the cooling air, which is

74 cub. m. per second, is forced through these ducts. The individual groups of laminations are separated from each other by fillets. Each sixth part of the stator weighs about 40 tons, inclusive of the winding.

Transport conditions also necessitated the division of the rotor into three wheels, which are arranged one above the other in an axial direction. Each wheel is divided into two halves, which are held together by three shrink rings. In addition, there are eight studs for fitting purposes. The total weight of the rotor, including the shaft and poles is 560 tons. The poles are bolted to the pole wheel and number 40 or 48, depending on whether the frequency is 50 or 60. Each pole weighs about 2·6 tons and exerts a centrifugal force of 800 tons at the critical speed. This force is taken up by six studs, which were pre-stressed to 500 kg. per square centimetre. In order to gain access to the inner bolts, four hand holes, 600 mm. in diameter, are provided.

As the total load is about 1,140 tons and the short-circuit torque is 6,300,000 kgm., a shaft diameter of 1,050 mm. was required at the hub and of 1,100 mm. at the lower bearing. The shaft is 10 m. long and, at the lower end, is fitted with a coupling flange, 1,650 mm. in diameter, for connection to the Francis turbine. It is bored through the centre with a hole 300 mm. in diameter and its finished weight is 65 tons. Owing to the large axial forces and short-circuit torque, a very massive foundation was required, with the smallest possible dimensions of the upper portion of the turbine housing. The proposed arrangement of the thrust bearing on the lower spider of the alternator had, therefore, to be abandoned, and the bearing is carried on the upper spider. From this the load is uniformly distributed over the stator housing to the foundation.

For reasons of transport, each part of the spider has only two integral arms, the other four being bolted on. Stiffness was the first desideratum and with a stress of 200 kg. per square centimetre, which includes the static load, the weights of the alternator rotor and turbine runner and its own weight, the deflection is about 1·2 mm. This deflection was compensated during erection. Between no load and full load the spider deflects from 0 mm. to 1·0 mm., according to the acceleration.

The thrust bearing is designed for an average surface pressure of 35 kg. per square centimetre at a speed of 16 m. per second. The thrust block consists of a steel casting. This casting contains a one-piece forged ring, from which it is insulated in order to eliminate stray currents. The thrust segments are also of cast steel, with bearing-metal linings. Their height is determined by the condition that the deflection of the wheels must be less than the thickness of the oil film. As, with a loading of 114 tons per segment, this condition could not be met by using one spring plate and a support in the middle, without making the segments too high, the spring plate was supported round the rim. This allowed the force of the spring to be doubled when the plate was equally loaded. The collar of the thrust bearing is extended and acts as the housing for the upper guide bearing. By combining the thrust and guide bearings in this way, it has been possible to simplify the oil supply arrangements and to guard against leakage. The lower guide bearing, which is also contained in a six-armed spider, is divided axially. Each of the constituent parts weighs 1·5 tons and is in two halves. Owing to the weight, special methods of erection had to be devised.

A volume of 74 cub. m. of air per second is required to dissipate the heat losses. For this reason a circulating cooling system was necessary. This consists of twelve coolers, which are arranged in groups of six between the machine housing and the external air jacket. This jacket is fitted with adjustable louvres, so that the warm air can be used to heat the engine room in cold weather. The louvres are automatically closed should a generator fire occur, and the closing mechanism also releases carbon dioxide. Each alternator is provided with a main and auxiliary exciter, which are supported on the thrust bearing above the rotor spider. In addition, there is an auxiliary generator for supplying current to the turbine governor. The machine is started by remote control from a central position, an arrangement which allows it to be run up in the shortest time and facilitates paralleling with other machines. A complete series of protective devices is also fitted.

Ardoloy in the Machine Shop.—Messrs. Alfred Herbert, Limited, Coventry, have recently sent us a little book entitled "How to Use Ardoloy." The booklet has been prepared for machine operators and contains detailed instructions regarding the cutting speeds and feeds and the top rake and clearance angles to be employed when using Ardoloy cutting tools for steel, cast and wrought iron, non-ferrous metals, and various non-metallic materials. Useful recommendations and hints on the sharpening of Ardoloy tools are also included.

INSTITUTION ELECTIONS.

Institution of Electrical Engineers.

Associate to Associate Member.—Alan Biddulph Cowen, Salisbury, S. Rhodesia; John Diggle, Prescot, Lancs.; Lieut. Percy Evans, R.E., Cardiff; William Fenwick, Hebburn-on-Tyne; Albert Henry Harvey Shanghai, China; Ernest Sidney Morris, St. Helens, Lancs.; Walter Herbert Owens, West Wickham, Kent; Walter Reginald Wheeler, Tidworth, Hants.

Graduate to Associate Member.—Arthur Quinton Allan, Milnthorpe, Westmorland; Redvers Arron, Leeds; Hubert Fozard Ashton, Stranraer, Wigtownshire; Richard Bradfield Besley, B.Eng., Madras, India; William Bernard Best, B.Sc. (Eng.), London, S.E.21; Gilbert Booth, Huddersfield; John James Bradley, London, S.E.19; Harold Brooks, Leeds; Michael Burton, B.Sc. Tech., Johannesburg, S. Africa; Charles Victor Cassal, Carshalton, Surrey; Frank Henry Cone, London, N.14; William Ernest Darby, Newcastle-under-Lyme, Staffs.; William Armon Duggan, Altrincham, Cheshire; Alan Fairweather, M.Sc., London, N.W.2; William John C. Fletcher, B.Sc. (Eng.), Newcastle-upon-Tyne; Alfred Hart, London, S.E.19; John Nelson Hefford, Leeds; Robert Pasifull Horlock, B.Sc., Brooklands, Cheshire; James Robert Lamacraft, Coventry; Arthur McCormac, Altrincham, Cheshire; James McFetridge, London, N.4; Thomas Harry A. Mascall, London, N.W.2; Rustam Johangir Master, Kowloon, Hongkong; Sydney David Mellor, B.Eng., Leeds; Philip Elworthy Peck, B.Sc. (Eng.), Rugby; Hubert Roberts, B.Sc. (Eng.), Llanelly; Ernest Heywood Scholes, Lancaster; Norman Seddon, Derby; Edward Clayton Smith, Stockport; Ernest Leslie Smith, Burghersdorp, S. Africa; William Edward Smith, Rugby; John Edmund Spear, Wolverhampton; Lieut. Roger Leslie C. Tessier, R.N.V.R., c/o G.P.O., London; Gerald Charles Tysoe, B.Sc., Bevere, Worcester; Basil St. M. F. Webb Ware, M.A., East Horsley, Surrey; Douglas Francis Welch, B.A., Rugby; Walter Weston, Manchester; Sub-Lieut. Thomas Scott Worthington, R.N.V.R., Portsmouth.

Institute of Marine Engineers.

Member.—James Tindle Adams, Glasgow; Simon Francis Boomer, Vancouver; Zygmunt Kuske, London; Thomas Moffett, Victoria, British Columbia; Archibald Nelson Platford, Gorleston-on-Sea; Stephen Bolten Trenoweth, New Milton, Hants; Ramon Zubiaga, London.

Associate Member to Member.—Frank Roy Samuel Wells, Cheam, Surrey.

Associate to Member.—Ellis Robert Chamberlain, Upminster, Essex.

Associate Member.—John Cook, Oxhey.

BOOKS RECEIVED.

The British Electrical and Allied Industries Research Association. Reference S/T35. *Surge Phenomena. Seven Years' Research for the Central Electricity Board.* (1933-1940.) London: Offices of the Association, 15, Savoy-street, Strand, W.C.2. [Price 50*s.* net.]

Mines Department. Eighteenth Annual Report of the Safety in Mines Research Board. Including a Report of Matters Dealt with by the Health Advisory Committee. 1939. London: H.M. Stationery Office. [Price 1*s.* net.]

Staffordshire Iron and Steel Institute. Proceedings. Session 1939-40. Volume LV. Edited by H. A. Mac Coll, Secretary. The Staffordshire Iron and Steel Institute, 87, Lincoln-road, Walsall, Staffs.

The United States Bureau of Mines. Technical Paper No. 618 (Supplement to Technical Paper No. 491). *Analyses of Washington Coals.* [Price 15 cents.] Technical Paper No. 619. *Mining Practices and Safety at the Laval Cap Gold Mining Corporation Mines, Nevada City-Grass Valley District, California.* By S. H. Ash. [Price 20 cents.] Washington: Superintendent of Documents.

United States Bureau of Mines. Technical Paper No. 620. *Accidents in the Oklahoma Petroleum Industry in 1937.* By C. F. McCarroll. Washington: Superintendent of Documents. [Price 15 cents.]

Ministry of Supply. Welding Memorandum No. 1. *Memorandum on Specifying Welds on Drawings and the Control of Arc Welding Procedure.* Welding Memorandum No. 3. *Memorandum on Jigs and Manipulators for Fusion Welding.* London: Advisory Service on Welding, Directorate of Scientific Research, Ministry of Supply, Great Westminster House, Horseferry-road, S.W.1.

Department of Scientific and Industrial Research. Road Research Laboratory. Wartime Road Note No. 1. Issued in co-operation with the Ministry of War Transport. *Recommendations for Tar Carpets and Surface Dressings.* London: H.M. Stationery Office. [Price 6*d.* net.]

PERSONAL.

Mr. W. Y. Sanderman, M.C., B.Sc., M.Inst.C.E., assistant engineer, Southern Area, London and North Eastern Railway, has been appointed engineer, Scottish Area, in succession to Mr. J. C. L. Train, who as stated on page 8 *ante* has been made engineer, Southern Area.

The Trustees of the late Mr. C. P. Sandberg, C.B.E., M.Inst.C.E., have arranged to carry on the business of Messrs. Sandberg, 40, Grosvenor-gardens, London, S.W.1, under the management of Mr. A. J. W. Graham, O.B.E., M.I.Mech.E., with the assistance of Mr. J. F. Sandberg.

Mr. Hugh Beaver, M.Inst.C.E., M.I.Chem.E., Director General of the Ministry of Works and Buildings, has been appointed official chairman of a new National Building Council, representative of the principal interests in the industry, recently established by the Minister of Works, in pursuance of the policy of co-ordinating the war-time building effort. Sir Ernest Simon is to be deputy chairman, and the names of the other members of the Council will be announced shortly.

Mr. A. W. Woodbridge, M.Sc., A.C.G.I., A.M.I.E.E., has been appointed assistant to the signal and telegraph engineer, Great Western Railway.

Mr. Horace Shakeland has been elected president of the Society of Motor Manufacturers and Traders in succession to Mr. W. E. Rootes, who was recently appointed deputy chairman of the Committee of Supply at the Ministry of Supply.

Mr. R. Townend has been appointed chief engineer of the Plant Department of Messrs. Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17, in succession to Mr. G. A. Juhlin, who was recently appointed chief electrical engineer to the firm.

The distinction of Fellow of the City and Guilds of London Institute (F.C.G.I.) has been conferred upon Dr. F. H. Carr, C.B.E., F.I.C., M.I.Chem.E.; Dr. J. V. Eyre, M.A.; Mr. J. Rosen, B.Sc.(Eng.), M.I.E.E., A.M.Inst.C.E.; and Sir Pierre Van Ryneveld, K.B.E., D.S.O., M.C., B.A., B.Sc.(Eng.).

Messrs. Specialloid, Limited, Friern Park, North Finchley, London, N.12, inform us that their Buenos Aires office is now under the management of Mr. R. J. Walker.

Messrs. The Brush Electrical Engineering Company, Limited, Loughborough, announce that their London office and that of Messrs. Brush Coachwork, Limited, has been moved from 88, Kingsway, to Bush House, North-West Wing, Aldwych, W.C.2. Furthermore, the London office of Messrs. Petters Limited, has been re-opened at this same address, and Mr. A. P. Quarrell, A.M.I.Mech.E., is resuming his duties as London manager. The new telephone number for these offices is TEMple Bar 6262.

Brush Scholarship Award for 1941.—This year's Brush Scholarship has been awarded to Mr. Raymond Pennington, of Scholes, near Leeds. Brush Scholarships are of the value of 75*l.* per annum and are tenable for four years, the first year of which is spent in the works of Messrs. The Brush Electrical Engineering Company, Limited, Loughborough, and the remaining three at any British University. After taking their degree, scholarship holders return to Loughborough for a final year of apprenticeship, during which they rank as second-year college apprentices. Particulars of the college and other apprentice schemes of the Brush Company were given on page 77, *ante*. Mr. Pennington intends to study for his degree under Professor W. E. French at the University of Leeds.

The Bennis Coking Stoker.—A new publication, which can hardly be described as a catalogue since it does not contain specific lists of manufactures, has just been issued by Messrs. Bennis Combustion, Limited, Little Hulton, Bolton. Its subject-matter is the Bennis coking stoker for natural and forced draught, and after a general description of the several types available a number of recently completed installations are described. Most of these descriptions deal not only with the boiler plant, but with the main features of the industry concerned, so that the application of the stoker is linked-up directly with production. These illustrative examples are, for the most part, accompanied by practical data, such as complete results of official boiler tests, or abridged results including the nature and calorific value of the fuel, rates of evaporation per pound of fuel, draught, CO_2 percentage, type of boiler, thermal efficiency, coal and ash analysis, and so forth. Excellent illustrations are provided in abundance, and these in conjunction with the straightforward text should make the brochure of value to steam engineers engaged either in laying-out new plant or extending or modernising existing plant. A short section at the end of the brochure indicates briefly what other parts of boiler-house plant, coal and ash-handling apparatus, are manufactured by the firm, through this auxiliary apparatus is dtealt wih in more detail in separate leaflets.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Active conditions were general in the Scottish steel and iron trades during the past week, following the resumption of business after the mid-summer holidays. Makers had to cope with quite a fair accumulation of orders. Boiler plates are in good demand and there is a steady flow of specifications from the shipbuilding industry for plates and other materials. Light structural sections are in steady demand, but business in the heavier materials has eased off to a certain extent. Makers of black steel sheets are still well booked up for the present and steady running of plant is assured for the immediate future. Prices are unchanged and are as follow:—Boiler plates, 17*l.* 12*s.* 6*d.* per ton; ship plates, 16*l.* 3*s.* per ton; sections, 15*l.* 8*s.* per ton; medium plates, ¼ in. and thicker, rolled in sheet mills, 21*l.* 15*s.* per ton; black steel sheets, No. 24 gauge, 22*l.* 15*s.* per ton; and galvanised corrugated sheets, No. 24 gauge, 26*l.* 2*s.* 6*d.* per ton, all for home delivery.

Malleable-Iron Trade.—In the West of Scotland malleable-iron trade recent bookings have filled up order books and the works are well employed. Raw material is not very plentiful at the moment as supplies of wrought-iron scrap have not been coming forward in sufficient tonnage for makers' requirements. The re-rollers of steel bars have still a large amount of work on hand and have lately secured some important orders which will ensure steady running for some time, but near date business can still be undertaken. The stocks of semies on hand are good. The following are to-day's quotations:—Crown bars, 15*l.* 12*s.* 6*d.* per ton; No. 3 bars, 13*l.* 12*s.* 6*d.* per ton; No. 4 bars, 13*l.* 17*s.* 6*d.* per ton; and re-rolled steel bars, 17*l.* 15*s.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—In the Scottish pig-iron industry, active conditions are still general and all furnaces in blast are working at full capacity. The demand from consumers is of a pressing nature, but the supplies of iron ore have been arriving in sufficient quantities for all requirements. The current quotations are as follow:—Hematite, 6*l.* 18*s.* 6*d.* per ton, and basic iron, 6*l.* 0*s.* 6*d.* per ton, both delivered at the steel works; foundry iron, No. 1, 6*l.* 5*s.* 6*d.* per ton, and No. 3, 6*l.* 3*s.* per ton, both on trucks at makers' yards.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—Work at the majority of the South Wales mines has been suspended throughout the past week on account of the miners' annual holidays. This resulted from a decision reached by the Conciliation Board that the men should take the whole of the August Bank Holiday week off. The decision was made necessary, following upon the miners' refusal to stagger their holidays. It will be recalled that their Executive recommended that they should take three days in August Bank Holiday week and three days later in the year. There was one important stipulation in the decision of the Conciliation Board, that at those collieries where production was essential for coke ovens, public-utility concerns and other vital services, the men should take only the Monday off. It was decided to leave it to the men at the collieries concerned to arrange with the managements when they would take their holiday and also whether they would close for a full week or arrange to take their holidays in batches. The miners have had under review the agreement proposed for Sunday working, which was rejected by a ballot of the lodges. A special conference was called, at which an explanation was given of certain points which had caused some misunderstanding among the men, and it was almost unanimously decided to refer the matter back to the lodges for reconsideration. The lodges reported back to the central office and the second vote showed a majority in favour of the scheme, which has been modified so that it provides for Sunday night work for preparation to the coal face in readiness for a quick start on Monday mornings. Conditions have not shown any material change on the steam-coal market during the past week. The demand from both home and foreign customers was sustained, but the amount of business that could be negotiated was still curtailed. Best large coals were still moving off satisfactorily under existing contract commitments, and the sized kinds were only sparingly available for some time to come. The strongest section of the market was still provided by the bituminous small grades which were extremely scarce. Dry steam smalls were plentiful and dull. Cokes and patent fuel were unaltered.

The Iron and Steel Trade.—Activities in the iron and steel and allied trades were maintained on a good scale during the past week. The demand was active and most works were engaged almost to full capacity on orders already in hand.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—The supply of iron and steel, although adequate for the actual needs of the war industries, does not yet justify free distribution of tonnage for other purposes, and cautious delivery allocations of certain descriptions of material are still necessary. Imports from America have been reduced, but would doubtless be restored promptly to their recent high level should the need arise. August holidays are not so extensive as usual, but the suspension of operations at some works has enabled essential repairs to machinery to be carried out. A satisfactory feature of the present position is the ample provision of raw materials and semi-finished products.

Cleveland Iron Trade.—Cleveland pig is still scarce, but users of foundry iron are accumulating stocks of brands from other producing areas. Deliveries of Midland iron to this district are still on a satisfactory scale, as also are supplies, from other sources, of certain qualities of iron required for special purposes. Merchants are obtaining control of rather more tonnage than formerly, but could dispose of larger quantities. The fixed prices of Cleveland qualities are ruled by No. 3 description at 128*s.*, delivered to local buyers.

Basic Iron.—The nominal price of basic iron remains at 120*s.* 6*d.* There is none for sale, but the output amply covers the requirements of producers' own steel-making plants.

Hematite.—The shortage of hematite is still marked and, as prospects of increased production are remote, only very small lots are licensed for delivery from essential requirements. The use of refined iron and steel scrap as a substitute is as extensive as possible. There is no likelihood of any relaxation of rationing, regulations for which are strictly enforced under the control of distribution scheme. Official quotations of East Coast hematite remain at the equivalent of 138*s.* 6*d.*, delivered to North of England customers.

Foreign Ore.—There is no less difficulty in securing ores for hematite making, but cargoes from abroad for other requirements are sufficient for current needs.

Blast-Furnace Coke.—Durham blast-furnace coke is abundant, but holders are not pressing sales. They are disinclined to negotiate extensively until they have reduced their contract obligations appreciably. Local consumers are well bought and are not desirous of placing new orders. The recognised values are based on good medium qualities at 36*s.* 9*d.*

Manufactured Iron and Steel.—Semi-finished iron and steel are plentiful and promise to continue in ample supply. Finished-iron manufacturers have substantial orders for heavy commodities, but would welcome new contracts for light descriptions of material. Steel producers have extensive rolling programmes. Pressure for delivery of ship, tank and boiler plates is unabated and priority attention is still accorded to shipbuilders' specifications. Some difficulty is experienced in meeting the demand for special alloy steels, and railway material is readily taken up. Producers of structural steel could deal with more work than they are turning out, but the lull in buying is expected to be of short duration. The output of sheets is on a reduced scale.

Scrap.—Inferior grades of iron and steel scrap are being offered fairly freely, but supplies of machinery metal, heavy steel and heavy cast iron are still barely adequate for requirements.

GAS COOKING APPARATUS FOR FEEDING CENTRES.—In a new pamphlet entitled "Feeding the Nation," gas-cooking apparatus, as employed in actual British Restaurants, emergency feeding centres, mobile canteens, potato bars, and other community-feeding schemes, is described and illustrated. Dual-purpose cooking equipment, which can be converted in a few minutes to burn either gas or coal, is one of the useful ideas contained in the pamphlet. The booklet, which is well written, is intended as a guide to local authorities on the subject, and copies can be obtained gratis on application to the publishers, The British Commercial Gas Association, 1, Grosvenor-place, London, S.W.1.

THE PORT OF COCHIN.—The annual report of the Administration of the port of Cochin, Wellington Island, South India, for the year ended March 31, 1940, has recently come to hand. This shows that the tonnage of imports and exports passing through the port during the year 1939-40, namely, 951,363, was not only greater by 165,234 tons than the total for the previous year, but was the highest figure ever recorded. Steamers, to the number of 622, and 532 sailing vessels, having an aggregate net tonnage of 1,732,452 and 30,374, respectively, entered the port during the year. Dredging operations and the construction of bridges, buildings, roads and other works were actively continued.

NOTICE OF MEETING.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTION OF THE RUBBER INDUSTRY.—*London and District Section:* Monday, August 11, 7 p.m., The Imperial Institute, South Kensington, S.W.7. Film Evening.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Most of the steel and engineering works in the Sheffield district are on holiday this week, and will not resume operations until Monday next. The flow of orders has been maintained. Steel producers report that output shows a steady rise as compared with a year ago. The market in raw and semi-finished materials is active, and consumers have little to complain of regarding deliveries. The demand for both basic and acid materials has increased. Makers of sections, joists, and plates are having difficulty in keeping pace with the demand, and works turning out structural steel are operating at full capacity. There is a good home market for various types of sheets, but export requirements are very restricted. Rolling mills, forges, and press shops are exceptionally busy, and re-rollers have well-filled order books. The heavy engineering branches report little change. Business shows improvement in railway rolling stock and related products, such as wheels, axles, springs, tyres and buffers, and Sheffield works are supplying their associated shipyards with an exceptionally heavy tonnage of machinery, steel, and tools. The recent run on heavy grinding and crushing machines has been well maintained. Makers of excavators, trenching machines, elevators, and similar machines report progress. Special-steel makers, despite the installation of new furnaces, are finding some difficulty in meeting the demand. Stainless steel, whether in the form of bars or sheets, is being absorbed in large quantities by various industries, including those manufacturing agricultural machinery, dairy equipment, food containers, textile machinery and mining plant. There is also a heavy call for acid- and heat-resisting steels. Progress has been maintained in the production of electrical machinery, and cement and concrete mixing machines are being ordered more freely. The tool-making branches are well placed with orders.

South Yorkshire Coal Trade.—All classes of coal are in strong demand, industrial fuel, in particular, finding a ready market; many works are steadily building up stocks. Steam coals are an active line, and locomotive coal is in strong request. Smalls and slacks are being supplied in larger quantities to electric power stations. The house-coal market is steady, but some merchants in this area complain of difficulty in obtaining supplies. The coke position is satisfactory.

ZINC OXIDE IN CHEQUER CHAMBERS.—According to data contained in a paper, by Messrs. J. H. Chesters and T. W. Howie, presented recently to the British Ceramic Society, zinc oxide is often present in appreciable quantities in the dust of chequer chambers of basic open-hearth furnaces. Experiments showed that much more fluid melts could be expected from silica bricks than from fireclay bricks when zinc oxide is present in the dust. In view of this, it is recommended that high-alumina bricks be used for the upper portions of the chequer work when high properties of zinc oxide are expected.

CONTROL OF CHROMIUM, WOLFRAM, DOLOMITE AND FOUNDRY BONDING MATERIALS.—The Minister of Supply has issued the Control of Chromium, Magnesite and Wolfram (No. 2) Order and the Control of Foundry Bonding Materials (No. 1) Order, both of which came into force on July 30. The first of these two Orders makes subject to licence the acquisition and disposal of basic or neutral refractory material, defined as including bricks, refractory cements and other refractory materials containing any compound of magnesium or chromium, other than those manufactured wholly from dolomite. The Foundry Bonding Materials Order subjects to licence the acquisition and disposal of bentonite, Colbond and fullers' earth, except for the dyeing and processing of textiles, oil and fat purification, paint and pigment manufacture, paper and board making, and the preparation of pharmaceutical products. In addition to the materials covered by these two Orders, the Chromium Controller, in future, will be responsible for the production and distribution of dolomite with a view to ensuring adequate supplies and the most advantageous use of the material. It is not considered necessary, at the present time, to regulate the sales of dolomite by licence. All inquiries regarding the new Orders should be addressed to the Chromium Ore, Magnesite and Wolfram Control, Ministry of Supply, Broadway-court, Broadway, London, S.W.1.

THE "BEAUFIGHTER" LONG-RANGE FIGHTING AEROPLANE.

(*For Description, see Page* 116.)

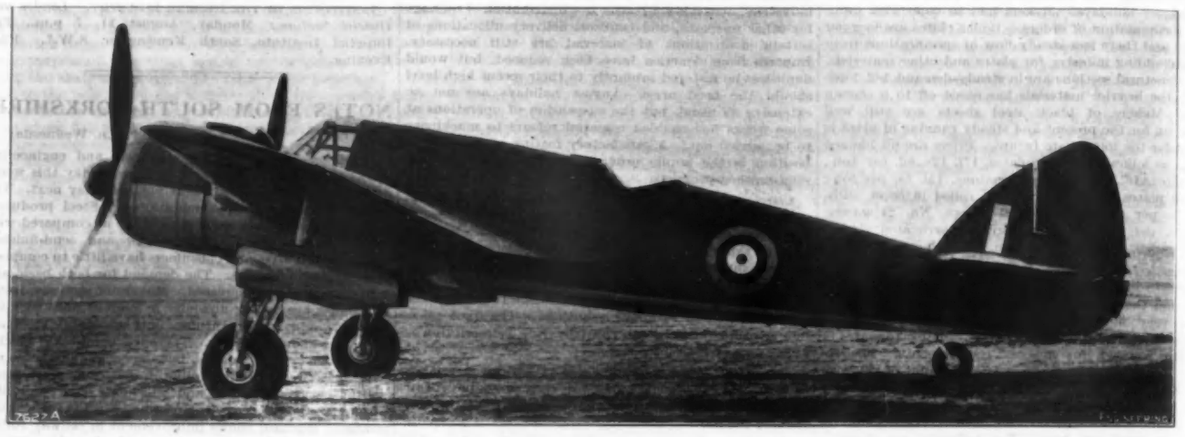


Fig. 1. Side View.

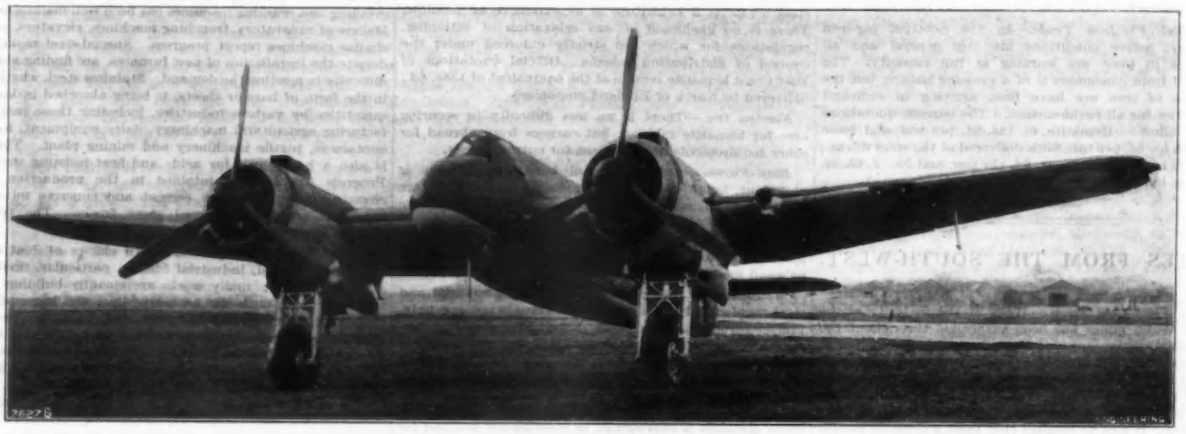


Fig. 2. Front View.

Fig. 3. Engine Cowling and Retractable Undercarriages.

Fig. 4. "Bristol" Hercules III Sleeve-Valve Engine.

ENGINEERING.

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The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines, or under, and one shilling per line up to one inch. The line averages six words. When an advertisement measures an inch or more the charge is 12*s.* per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns, of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but cannot be guaranteed.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The Proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

All accounts are payable to "ENGINEERING," Ltd. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post Office Orders should be made payable at Bedford Street, Strand, W.C.2.

TEMPORARY ADDRESS.

For the duration of hostilities, the Editorial and Publishing business of this Journal is being conducted from 18 and 20, Compton Road, Hayes, Middlesex. The Telephone Number of the Editorial Department is Hayes 1730, and that of the Publishing Department, Hayes 1723. The Bedford Street Offices are open on Fridays only, between 10 a.m. and 5 p.m., for the distribution of the current issue and for retail sales.

INDEX TO VOL. 151.

The Index to Vol. 151 of ENGINEERING (January–June, 1941) is now ready and will be sent to any reader, without charge and postage paid, on application being made to the Publisher. In order to reduce the consumption of paper, no copies of the Index are being distributed, except in response to such applications.

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ENGINEERING

FRIDAY, AUGUST 8, 1941.

VOL. 152. No. 3943.

OBJECTIVES IN STEAM LOCOMOTIVE DESIGN.

WHATEVER may be said in disparagement of the locomotive engineer's reluctance to embark on radical departures from traditional design, it has to be admitted that the overall performance demanded of average locomotives in day-to-day service, as distinct from theoretical efficiency, is a weighty argument in favour of a cautious approach towards changes which, as past experience has repeatedly shown, often proved to be as disappointing in the event as they are promising in prospect. Too often the advocates of revolutionary ideas have seen no more than a single aspect of a wide problem involving a great many inter-related factors. They have lacked the comprehensive vision which has regarded the technical side of locomotive design as subsidiary to the commercial success of the railway, and which has leavened the originality of the most outstanding designers with a conservative respect for reliability, availability, cheapness of maintenance, and ease of operation in the broadest sense of the term. This attitude has undoubtedly exerted a powerful influence on the development of the steam locomotive in Britain, and it is difficult to escape the conviction that there is something essentially sound, despite its shortcomings, about the conventional type of engine, which goes on giving good and faithful service year after year. Experimental locomotives, on the other hand, have not been conspicuously successful. They enjoy a brief hour of glorious publicity, but they have a way of disappearing from the news, never to be heard of again unless, ignominiously, they come to be rebuilt along conventional lines. Sometimes the experiments may have been too half-hearted to command success, or their sponsors less pertinacious than if there had been no existing rail transport to contend against. There may even be some grain of truth in the view that, by a sort of natural selection through many generations of designers, the most suitable form of locomotive for the needs of this country has already been evolved, at least so far as major principles of design are concerned.

The unattractive prospect of finality in locomotive development, thus implied, is fortunately not borne out by the very substantial technical progress that is still being achieved and which, within recent years, has produced noteworthy improvements in power, speed and availability. Such progress follows from perfection in points of detail, however, rather than from any markedly successful change of principle. In this country, indeed, the limitations imposed by the gauge of track and tunnels; to a less extent, by the strength of bridges; and by the predominance of coal among the national power resources, must inevitably and permanently affect the directions in which steam locomotive design can profitably be advanced. Conditions in the United States of America are appreciably different. In particular, the abundance of home-produced oil fuel has there introduced serious competition, first, of road against rail transport, and, latterly, of oil-engines against steam power upon the railroads. The many favourable characteristics of the internal-combustion engine have created new standards of train service and luxurious travel, which a wealthy population, eagerly served by enterprising road transport, can insist upon receiving. The result is that the most powerful steam locomotives in the United States are unable to meet the combined demands of rapid acceleration, sustained high speed and heavy trains, on the scale already envisaged for the near future.

It is instructive, in this connection, to compare the power requirements, deduced from tests undertaken by the Association of American Railroads, with figures for the available draw-bar horse-power of large modern locomotives, published by the International Railway Fuel Association. They reveal the inadequacy of the present steam locomotive, but they also suggest that the comparable Diesel-electric locomotive is not so superior as to put steam power out of the running. On the contrary, indeed, the advantage appears to lie with the steam locomotive at the higher speeds. In Britain, as well as on the Continent and in America, the new standards of speed set up by Diesel trains have stimulated steam engineers to equal and even to surpass them, probably at considerable cost in operating expenditure, but without recourse to fundamental changes other than streamlining.

There is thus the more justification for renewed effort to exploit the potentialities of the steam drive. That a wide field for improvement remains incompletely explored has long been apparent from the much higher efficiencies achieved in electric power stations, and it is to be expected that increased locomotive efficiency should be sought among the essential items of power-station practice. In this respect there is little of novelty or note about the survey* of design objectives which Mr. Ostermann, vice-president of the Superheater Company, Chicago, contributed to the annual meeting of the American Society of Mechanical Engineers, held in New York last December. Mr. Ostermann's list of requisites for the super-locomotive includes all those upon which the high efficiency of modern stationary steam plants has been founded. Automatic firing, high steam pressure, water-tube boiler, high superheat, steam turbine, condenser—how familiar they are; how excellent their established reputation; and how difficult to utilise profitably on locomotives. In every case it is not the knowledge, but the achievement, of the objective that has taxed the engineer's ingenuity and has often brought a crop of subsidiary associated troubles in its train. Mechanical firing is expensive; the high-pressure fire-tube boiler is heavy; the water-tube boiler, built within British railway gauge limits and using water from many different sources, gives unsatisfactory circulation and too little reserve of steam; high-temperature steam leads to lubrication troubles; turbines are wasteful of steam at low speeds, and need condensers for efficiencies comparable with those of stationary plant to be realised; while condensers make extravagant demands in fan power, and represent so serious an increase of weight as often to be omitted from turbine locomotives after exhaustive consideration of the consequent detriment to thermal performance.

To do Mr. Ostermann justice, it is fair to say

* "Modern Objectives in Steam-Locomotive Design," by R. M. Ostermann. *Mechanical Engineering*, vol. 62, page 801 (1941).

that he is not unaware of the formidable amount of research and development work that will be necessary to bring his objectives within the sphere of practical achievement, though the admission does nothing to further the constructive value of his paper. Moreover, the fact that he addresses himself primarily to American railwaymen makes him overlook many additional factors which would tend to restrict the full achievement of his suggested objectives in British practice. He does, however, make one or two general points which deserve to be kept carefully in mind when principal changes of steam-locomotive design are projected. One such point is the inter-relationship between the several requirements of the most desirable machine. Minimum fuel costs per unit of power output, for example, demand ultra-high boiler pressure and steam temperature. These, for reasons of weight, point to the use of the water-tube boiler, which in turn needs pure feed water, thus indicating a function of the condenser to which, perhaps, too little regard has been given.

Mr. Ostermann, in stressing this particular function of the locomotive condenser, is inclined to urge that it is even more important than the improvement of thermal efficiency associated with the increased heat drop that a condenser makes possible. He would have an air-cooled condenser of limited weight and proportions, absorbing only a moderate fan power, and permitting such a proportion of the theoretically possible heat drop to be utilised as would lead to the optimum overall results in operation. Conceding that engine availability is worth a good deal in terms of fuel cost, he is prepared to recommend condensation even at the cost of some increase in fuel consumption. When fuel costs are viewed in correct relationship to the total cost of railway operation, there is certainly force in the argument, though, equally, the corresponding improvement of availability needs to be evaluated before the problem can be seen as a whole in true perspective. To estimate values of this sort obviously calls for a fairly large-scale experiment over a lengthy period, and only after this is it feasible to weigh up the conflicting factors affecting the design; whence it follows that the optimum engine must largely be the outcome of prolonged experience and gradual development. For experimental purposes, however, there does seem to be a case for making a number of interacting changes of design simultaneously, and not one at a time as, perhaps, has been the tendency hitherto.

Associated with automatic firing, Mr. Ostermann envisages boiler-feed control as necessitated by the small steam and thermal storage capacity of a water-tube boiler. The sensitivity of such boilers to the rapid fluctuations of load encountered in locomotive working is a matter for serious consideration, and it would be almost impossible even for oil burners, much less for mechanical coal stokers, to adjust their rate of firing to give adequate compensation when automatically controlled by boiler pressure. Automatic feed-water supply is under a similar disadvantage. In default of any constructive ideas on this problem, Mr. Ostermann contents himself with the very obvious observation that its solution challenges the ingenuity of the locomotive designer. It certainly does. Indeed, the whole principle of the exclusive use of condensate for feed water seems to turn upon it, since losses from safety valves and injectors assume much more importance than with non-condensing machines. Moreover, with increasing engine power a stage will come—not very much in advance of the biggest locomotives now in service on British railways—when hand firing will be beyond the capacity of one fireman. Far from the fireman being dispensed with, however, he will no doubt fulfil a higher function, aided by his knowledge of the road ahead, as a super-control over the automatic and mechanical contrivances devised to help him.

Like most proponents of the ideal, Mr. Ostermann has been unable to resist drawing a tentative picture of the locomotive of the future. It develops 6,000 h.p. at 80 miles an hour, and consists essentially of two identical engines connected back-to-back to a common fuel tank which is mounted above an articulating centre truck. It weighs less than 70 lb. per horse power and has a maximum draw-bar pull of over 50 tons. Hence almost all the weight is carried on swivelling trucks at the ends, each truck having four power-axles, driven through reduction gearing by a high-speed turbine capable of being compounded at starting and of being assisted by a directly-coupled auxiliary prime mover for low-speed work. Judged by advances in locomotive design during the past hundred years, these almost revolutionary proposals of Mr. Ostermann represent the better part of another century of development. Even the most ardent advocate of steam locomotion may be pardoned for thinking that this is looking a little too far ahead to be useful, and that objectives somewhat nearer to hand will have more chance of being accomplished within the working lifetime of those who study them. This does not mean, however, that less ambitious experimental projects may not, with advantage, be drawn up with ultimate objectives in mind such as Mr. Ostermann has formulated, nor that the remoteness of their realisation should justify any relaxation of steam-locomotive development. Experimental work on the scale warranted by the wide and lasting issues at stake must obviously wait until the war is over; but, since the post-war years are likely to see some remarkable advances in all forms of transport, any time that can be spared now for constructive thought and preparatory planning may prove to have been well spent in the interests, not only of the home railways, but also of the country's markets abroad.

THE PURIFICATION OF SALT WATER.

There is, perhaps, no plight more pitiful than that of seamen adrift in mid-ocean with "Water, water, everywhere, Nor any drop to drink." The brutal German disregard of every humane tradition of the sea has, unfortunately, made such tragedies only too common. That men, surrounded by an unlimited expanse of water, should be condemned to perish miserably of thirst is a challenge to every engineer and physicist to find some means of preventing such happenings. The urgent need for some method of rendering sea water potable, which could be employed by the crew of a raft or open boat, was recently called to public attention by a correspondent of *The Times*, and our contemporary emphasised the matter in a leading article. The publicity thus given to the question resulted in various suggestions being received, none of which unfortunately, seems to afford any practical solution of the problem. The provision of a small distilling plant, similar to those used on board ship, has obvious disadvantages. The weight and size of the apparatus, together with the necessity for carrying a supply of fuel for its operation, would appear to be prohibitive. It is obvious, moreover, that any distilling equipment that is carried will take up space that might otherwise be occupied by extra storage tanks, filled in advance with drinking water. This objection applies equally to all kinds of purifying apparatus, of which several alternatives to evaporators might be proposed. One correspondent suggested that, if sea water could be frozen, the ice, being free from salt, might be re-melted to form drinking water. Theoretically, such a procedure might be possible, but the provision of the power or the fuel to operate a refrigerating plant in a small boat would appear to be quite impracticable, apart from the bulk and weight of the equipment. Another writer thought that perhaps salt might be removed by some method of dialysis, but it would seem easier to get salt into water than out of it by this principle. A third made the pleasant suggestion that the salt could be precipitated by the addition of silver citrate to the water, converting the water into a sort of "synthetic lemonade" that would be innocuous and not unpalatable. It did not appear, however, that he had submitted it to a practical test.

Sea water varies in composition, but an average sample may be taken to contain about 2,560 grains of dissolved solids per gallon, of which some 2,000 grains are sodium chloride, *i.e.*, common table salt. The principal other salts in solution are about 240 grains of magnesium chloride, 150 grains of magnesium sulphate and 90 grains of calcium sulphate. Chemically pure drinking water is neither possible nor desirable, but how much of the above substances could be absorbed daily without harm to the human organism is a question for medical men rather than for engineers. The most heavily loaded public water supply of which we are aware in this country contains only 63 grains of dissolved solids per gallon, of which 18 are chloride of sodium, 18·5 are sulphate of magnesia and 20·5 are carbonate of lime. It is probably not necessary to attain anything like this degree of purity in an emergency supply of drinking water, and, indeed, many reputedly wholesome beverages are, in comparison, almost stiff with matter in solution; but 2,000 grains of salt to the gallon, to say nothing of other chlorides and sulphates, appears to be definitely beyond the limit of what the ordinary human constitution can bear.

The field for devising means of reducing these quantities to a tolerable proportion is open to all who have a sufficient knowledge of the problem. Engineering, physical, and chemical schemes, as we have seen, have all been proposed, but the number of possibilities has by no means been exhausted. The ordinary salt, for example, might be removed by a base-exchange process, the converse of that which takes place in a zeolite water softener, but, unless there was some way of eliminating the resulting calcium chloride, the last state of the water would be as bad as the first. Alternatively, it seems conceivable that air could be saturated with the vapour of sea-water, and the moisture afterwards condensed out without too great difficulty. The process would be a slow one, but experience has shown that even a few teaspoonfuls of fresh water a day are sufficient to sustain life. The idea, at any rate, may be worth considering. There is, again the possibility that the salt content of sea water might be sufficiently reduced by some simple apparatus on the lines of the Hele-Shaw stream-line filter. We are under the impression, indeed, that some such claim was made for this device when it was first introduced, and it is certainly capable of filtering out every trace of colour from water deeply stained by a fast dye, which is beyond the power of any ordinary method of filtration.

More hopeful than any of these, perhaps, is the process which was investigated some six or seven years ago in the Chemical Research Laboratory of the Department of Scientific and Industrial Research. It was demonstrated at the conversazione of the Royal Society in 1935 and briefly mentioned in the account of the exhibits which appeared in our issue of May 17 in that year. The process was based on the properties of certain synthetic resins of absorbing the various constituent salts in sea water from solution. Four tubes were employed, the first and third being filled with particles of a synthetic resin prepared from tannin materials, while the second and fourth tubes contained a synthetic resin prepared from aniline. Ordinary sea water was passed through the four tubes in series, the metallic constituents of the salts being removed by the first and third tubes and the acidic constituents, combined with the metals, in the other two. The water issuing from the fourth tube, we recorded, was drinkable and free from inorganic matter. After a time, the resins ceased to be effective, but they could be regenerated in a similar manner to that employed with the natural and artificial zeolites used in some water-softening plants. We were given to understand at that time that the process was still in the laboratory stage and that its economics had not been studied, and do not recall any report of later developments; but the cost should not be excessive, as the materials from which the resins were prepared cost only a few pence a pound, and the apparatus itself is of a simple character. Inherently, the problem of rendering salt water potable should not be more difficult of solution than that of revivifying exhaled and otherwise foul air, which may now be regarded as completely solved; and a little determined investigation along the various lines that seem most promising might well result in almost incalculable benefit to the seafarers to whom the nation owes so much at the present time.

NOTES.

LECTURES ON FOREMANSHIP.

COURSES of lectures on foremanship are being organised by the Ministry of Labour and National Service, in conjunction with the Board of Education and the Scottish Education Department, at technical colleges in a number of industrial areas, contingent upon there being sufficient local demand for such a course in any particular locality. The lectures will cover the general principles of foremanship and supervision, the principles of production and planning, the elements of labour management, and costing and remuneration. The courses will normally be of 72 hours' duration and will usually consist of evening meetings of two hours each, held twice a week. No allowances or expenses will be paid by the Ministry of Labour and National Service to students attending the courses, but they will not be charged any fees. "It is appreciated," states the notice announcing the courses, "that both personality and considerable technical experience are required to make a foreman, and that it is impossible to produce one simply by a course of lectures. The intention of the courses is to give the wider background which will be useful to men already possessing these qualifications. On this account, only existing foremen and other men with the necessary experience will be accepted, and only these should apply for admission to the courses." Employers are invited, also, to put forward men of this type whom they consider likely to benefit from taking the course. Names and addresses of applicants should be sent to the local Employment Exchange, with a reference to the scheme, and accompanied by full details of the individual's technical experience and present employment. Those who have applied will be notified when the number of applications justifies the establishment of a course in their locality. An examination will be held at the conclusion of each course, and a written statement will be given by the technical college to those who pass it.

FENCHURCH-STREET STATION CENTENARY.

Fenchurch-street station, the first railway terminus to be constructed within the boundaries of the City of London, attained its centenary on August 2, the extension of the London and Blackwall Railway from its original terminus at the Minories having been brought into service on that date in 1841. The line was about 3¼ miles long, laid with two tracks of 5-ft. gauge, and was opened on July 6, 1840, between the Minories and Blackwall, with intermediate stations at Shadwell, Stepney, Limehouse, West India Docks and Poplar. It was operated by rope haulage, the power being provided by side-lever stationary engines at each end of the line. The engines at the Minories were constructed by Maudslay, Sons and Field, and were in duplicate, each set being of 224 nominal horse-power. The engines at Blackwall were generally similar in design, but were of 140 horse-power only, and were made by Barnes. The haulage rope was not carried on to Fenchurch-street when that station was opened; although there was a rising gradient of 1 in 150 from the Minories to Fenchurch-street, it was found that the coaches could surmount the rise by their own momentum after being slipped from the rope shortly before reaching the Minories. The method of working was original. The down train was made up at Fenchurch-street with a separate coach or coaches for each station and ran by gravity to the Minories, where it was attached to the rope. At the same time, the up train left Blackwall, also running by gravity to a point outside the station, where the Blackwall engine-house was situated, to be attached to the up rope. When both trains were ready, signals were exchanged by means of Wheatstone's telegraph and the engines were started. As the down train approached each successive station, the appropriate coach was slipped, and remained in that station until the time for the return journey. It was then attached to the rope and hauled back to the terminus. Thus, the train left Fenchurch-street as a unit, but returned as a succession of detached coaches, at intervals corresponding to the distances between stations; and each track served as both up and down routes in turn. The ropes were originally of hemp, but constantly gave trouble by twisting and breaking. Wire ropes, with a swivel at every half-mile, were substituted and proved to be relatively satisfactory. The service was frequent—quarter-hourly in each direction from 8.0 a.m. to 10.0 p.m. during the summer months and from 8.30 a.m. to 9 p.m. in the winter—and the journey time by the through coaches between the termini was only 13 minutes. It was stated at a meeting of the Institution of Civil Engineers, in 1846, when a paper by Mr. A. J. Robertson, on the haulage system, was being discussed, that "the charges for the motive power, for the year 1845, amounted to 11,302*l.* 1*s.* 2*d.*," representing 1*s.* 6¾*d.* a mile and, presumably, including the cost of rope maintenance and renewals. Unfortunately, the "two drawings, Nos. 3797 and 3798, giving the general plans and the details of construction of the machinery of the line," which illustrated Mr. Robertson's paper, were not reproduced in the *Proceedings*; and, on inquiry at the Institution some years ago, we were informed that no trace of the originals could be found. Rope haulage was discontinued in July, 1849, and the machinery was removed. The engines from the Minories are understood to have been used for many years in the City Mill at Blackfriars.

MERCURY-VAPOUR DANGERS IN SCIENTIFIC LABORATORIES.

Breathing air containing mercury vapour may result in a slow poisoning, having undesirable mental and physiological effects, and as mercury is a common working substance in scientific laboratories considerable attention has been paid to the possible effect of its presence on the health of workers constantly engaged in them. The most usual source of an excess of vapour is probably mercury accidentally spilled on a floor or bench. In one case on record, nearly 100 ml. of mercury was discharged from the top of a burette and fell about one metre on to a bench below. The room was 20 ft. by 18 ft. by 11 ft. and was ventilated by eight complete changes of air per hour. The temperature was 25 deg. C. The air at a point 6 ft. from the bench and about 4 ft. 6 in. from the floor was found to contain 120 μg. of mercury per cubic metre 15 minutes after the mercury was spilled; 24 hours later the concentration had decreased to 60 μg. per cubic metre, and after a further 28 hours, to 35. The bench was then shaken by blows from a mallet and in 10 minutes the concentration had again risen to 120 μg. per cubic metre. The explanation of this is that exposed mercury surfaces gradually collect a protective film of oxide, grease, etc., and disturbance breaks this up. As mercury in falling tends to spatter in small globules, too small to be seen without a microscope, the effects of an accident may endure for long periods. The National Bureau of Standards, of the United States Department of Commerce, has recently investigated the subject and measured the mercury concentration in its own and other laboratories. Its findings are given in a paper entitled "Hazard of Mercury Vapor in Scientific Laboratories" which appears in the May issue of its *Journal of Research*. In all, 61 laboratories were examined; of these, 28 showed less than 4 μg. of mercury per cubic metre of air; 16 showed amounts varying from 4 μg. to 12 μg.; seven gave figures up to 20 μg.; and ten amounts up to 70 μg. The investigation showed that the degree of concentration was determined almost entirely by the ventilation provided and that if this were adequate the relation between the amount of mercury in use and the size of the laboratory had little influence. The paper contains a section contributed by the National Institute of Health giving the results of the examination of laboratory workers. It states that only in cases of exposure to concentrations of more than 100 μg. was mercurialism found. As this is considerably in excess of the figure found for the laboratories examined, it would appear that mercury poisoning is not, in general, a present danger. As its effects are serious, however, the matter should not be ignored. In a laboratory concerned with electrical resistance measurements, a concentration of 70 μg. was found and it would appear that in such a case a dangerous figure might be approached if the ventilating plant were not properly maintained.

WAR-TIME TRENDS IN SOUTH AMERICAN MARKETS.

LATIN America's difficult problem of the disposal of unwieldy commodity surpluses, accumulated through loss of European markets, appears somewhat less threatening than at the end of 1940. Important alleviating factors have been the rearmament programme in the United States and, to a lesser extent, in Canada, and also the intensification of inter-trading between the South American republics. Imports from Latin America into the United States in 1940 expanded in value, over those for 1939, by some 20 per cent., but exports from the United States southwards increased by about 28 per cent. North America's exports, however, tended to fall in the later months of the year; which, combined with Washington's desire to co-operate economically with Latin America, and the recently accelerated industrial *tempo* in the United States, holds out some encouragement for an ultimate solution of the problem of Latin America's large adverse trade balance with the United States. This balance was largest in the case of Argentina, where it reached some 170 million pesos in 1940, but this was converted into a balance favourable to Argentina of some 138 million pesos in the first five months of 1941, through drastic cuts in Argentine imports and a large increase in exports northwards of wool, hides and skins. Under war-time conditions it is inevitable that the lion's share of trade with South America should now fall to the United States, but it should be remembered that the latter's co-operation in assisting to avert a first-class economic crisis in South America, and especially in supporting the foreign exchange markets by purchases of produce, granting credits, etc., is of direct benefit also to those other countries, including Britain, which are still able to trade with South America and which look forward to the resumption of normal trading when hostilities cease.

Under a recent decree, the Argentine Government abolished the import permit system, as from July 1, 1941, in respect of about 80 per cent. of total imports, including those from the sterling area. The official explanation stated that the change was designed to encourage imports, which would use up balances of blocked exchange, and to foster imports from neighbouring countries; and that the remaining restrictions upon 20 per cent. of imports would apply to goods of a luxury or non-essential nature. The fact that the new decree provided for the closure of the Exchange Control Office gave the impression that the Argentine exchange control system itself was to be suppressed. In fact, however, the title "Exchange Control Office" was really a misnomer, seeing that control of all exchange operations has been exercised by the Central Bank ever since that Bank was formed in 1935; a more correct description would have been "Import Control Office," as its principal function was to regulate imports. It is important to note that the control of exchange operations by the Central Bank continues intact, and there is no reason to expect any modification in ruling rates of exchange as a direct result of the decree.

Since December 1, 1938, permits have been compulsory in Argentina for practically all imports, so that general relief was expressed at the relaxation of vexatious regulations, which, in any case, had become superfluous because import permits for goods included in the exempted 80 per cent. had, in fact, been granted freely for some time past. The decision to relax import control was undoubtedly accelerated by the urgent import requirements of the increasing national manufacturing industries, coupled with the growing shortage of shipping even to and from the United States; and also especially by reason of the larger supply of dollars in the exchange market, resulting from the swing-round in the trade balance with the United States. The view is taken in North American trading circles that the relaxation of the import-permit regime in Argentina indicates that country's intention to facilitate trade with the United States, following upon other exchange concessions in respect of motor-vehicles, agricultural implements, etc.; and that Argentina will be allowed to obtain from the United States iron and

steel products equal to normal pre-war supplies from all sources. Whatever justification there may be for this view, the fact remains that most of Argentina's imports of American motor-cars, agricultural machinery and similar goods is paid for at the auction rate of exchange, which represents a much higher exchange cost than the rate paid in the official exchange market used for British goods. Actually, the recent changes in the Argentine regulations do not affect the present smooth provision of exchange for British goods, for which the rate of exchange is 17 pesos per £ for most imports.

While it would appear that Argentina, so far, has been justifiably regarded as one of the few safe refuges for foreign capital, there must not be overlooked the extent to which the country's financial outlook is being worsened by abnormal war-time trade conditions. It is true that the general exchange position seems to be strengthened by the favourable balance of trade recorded at the end of May, 1941, of 182 million pesos. This goes far towards establishing the balance of some 400 million pesos required annually to equilibrate international payments; but, in fact, it was achieved only by a drastic cut in the total value of imports of nearly 42 per cent., inasmuch as exports fell by over 26 per cent. Argentina is still faced with the problem of very large unsaleable stocks of grain, principally maize, which is being burned as fuel. The national finances are becoming increasingly embarrassed by the cost of buying grain from farmers at guaranteed prices, and a pointer to the general fiscal position is the announcement that the proposal to buy the British-owned Argentine railways has been dropped. It is also becoming extremely unlikely that the Argentine Government will grant any concession to the railways for increases in freight rates; this will mean increasing inability to purchase replacements of railway engineering items, which have formed an important part of imports in past years. Actually, gross receipts of all Argentine railways in the first eight months of 1940–41 were 8 per cent. lower than in the like period of 1939–40. Moreover, the results of the City of Buenos Aires Transport Corporation, covering the first complete year's working, show a deficit of over 13 million pesos, due to the fact that all the transport services had not yet been incorporated, and aggravated by higher costs of materials and increases in wages.

As already mentioned, Argentine imports are being severely cut this year, the total value during the first five months of 1941 having been only 412 million pesos, against 707 millions in the like period of 1940. Imports of engineering and allied items this year were as shown Table I, herewith. The comparable figures for the similar period of 1940

TABLE I.—*Imports into Argentina (Thousands of Tons and of Pesos).*

—	January-May, incl., 1941.		January-May, incl., 1940.	
	Quantity. Metric Tons.	Value. Pesos.	Quantity. Metric Tons.	Value. Pesos.
Fuel and lubricants	1,229·0	58,786	1,781·0	79,137
Chemicals, oils, paints, etc.	65·3	33,705	105·0	47,600
Iron and steel manufactures	116·2	20,094	315·9	52,049
Metals (excluding iron) and manufactures	34·5	17,699	71·1	32,384
Machinery and vehicles	22·4	18,708	68·2	53,154
Timber and manufactures	183·0	15,452	181·5	18,482

are given in the same table. Moreover, the fuel situation continues to deteriorate, imports of coal during the first quarter of 1941 having averaged only 80,000 metric tons a month, compared with the pre-war figure of 300,000 tons. The Argentine Government are taking various measures to deal with this situation, and, in addition to studying the possibilities of developing national coalfields, have authorised the National Fuel Board to control the importation and distribution of fuel. The granting of import permits for fuel will be conditional, in future, upon the purchase of a certain proportion of maize for fuel.

In the neighbouring republic of Uruguay, work on the important Rio Negro hydro-electrification scheme appears to have been definitely suspended until after the war. However, conditions are becoming increasingly encouraging, the loss of European markets for wool—the chief export product—having been more than compensated by large sales to the United States at good prices, while there have been substantial meat shipments to Britain. Consequently, there are indications of increasing ease in the exchange market, exemplified by the higher monthly import-exchange quotas granted to supplying countries, particularly the United States and Britain. The American quotas include principally raw materials, iron and tinplate, agricultural and industrial machinery, motor-vehicles and lubricants. The exchange quota granted to Britain was increased from 400,000*l.* in April, 1941, to 500,000*l.* in May, and again to 750,000*l.* in June.

Compensating for the loss of European markets for coffee, the United States is building up large stocks of that commodity (due to fears of transport difficulties and that the United States may become a belligerent), and sales by Brazil, Colombia and the Central American "coffee" States have been substantial, and at ever-increasing prices. Consequently, the foreign exchange position in Brazil continues normal, with every prospect of continuing so. Colombia has benefited even more than Brazil by the sharp rise in coffee prices, and, indicative of the betterment in the exchange position, the time-lag for remittances in respect of deferred imports has been reduced to one month, while advance permits in payment of all imports may now be effected, under stipulated conditions. With expanding markets for most products, particularly coffee and cotton, Brazil's total exports during the first four months of 1941 rose in value by about 9 per cent. over those of 1940; but the establishment of a favourable trade balance at the end of April of some 372,000 contos (one conto = 12*l.* 10*s.*) was due mainly to a cut in imports of nearly 20 per cent. American goods this year represented 59 per cent. of Brazil's imports by value, against 48 per cent. in the first four months of 1940, and those from Britain only 8·3 per cent., against 8·9 per cent. Brazil's imports, from all sources, of engineering and allied merchandise during the first four months of 1941 compared are shown in Table II, herewith, with those in the like period of 1940.

Brazil continues apace with the national policy of developing transport and the national manufacturing industries. The final contract has been signed between the Export-Import Bank of Washington and the recently-constituted National Steel Company in Brazil, for the loan of 20,000,000 dols. for the purchase in the United States of materials and installations, and the construction of the new

TABLE II.—*Imports into Brazil (Value in Thousands of Contos).*

—	Jan.-April, incl., 1941.	Jan.-April, incl., 1940.
Iron and steel manufactures	132·96	191·62
Generators, motors and other electrical machinery	76·42	52·51
Other machinery, and tools	214·11	244·87
Motor cars, lorries and chassis	92·39	95·66
Accessories for motor vehicles	69·49	63·52
Petrol and oil	104·95	181·32
Coal, coke and patent fuel	77·42	84·43
Chemical and pharmaceutica products	87·3	99·16

plant will be started very shortly. Already, in 1940, the output of iron and steel in Brazil included 185,300 metric tons of pig iron, 135,300 tons of laminated iron and 141,000 tons of steel, the corresponding figures for 1939 having been 160,016 tons, 100,996 tons and 114,095 tons, respectively. Notwithstanding the expansion in national production, imports of unmanufactured iron and steel last year were higher, at 95,780 tons against 90,502 tons in 1939, although arrivals of iron and steel manufactured goods fell in volume to 198,452 tons from 237,353 tons. Moreover, the coal-mining industry is favoured by Government measures, and the output in 1940 increased further to 1,350,000 metric tons, compared with 1,046,000 tons in 1929, whereas imports fell from 1,201,000 tons to 1,149,500 tons. Similarly, the production of cement in 1940 reached 743,634 metric tons, against 697,793 tons in 1939, while imports fell from 41,100 tons to 19,237 tons.

Although Chile's exports of copper, nitrate, etc., to the United States are increasing through armaments demands, there is little likelihood of relief to the present stringency to pay for sterling imports, unless Britain buys further amounts of agricultural products. Over the complete year 1940, the United States supplied 47·9 per cent. of Chile's imports by value, against 31·1 per cent. in 1939; and Britain 10·4 per cent. against 8·3 per cent. In Peru, Britain is negotiating for the purchase of a further

TABLE III.—*Imports into Chile (Thousands of Pesos).*

—	1940.	1939.
Iron and steel, and other metals and manufactures	64,185	57,807
Railway and tramway equipment	20,311	4,147
Other transport material	32,675	36,616
Electrical material	14,188	13,524
Motors, boilers, etc.	9,035	7,869
Mining and agricultural machinery and equipment	8,031	7,035
Other machinery and tools	25,361	27,938
Crude petroleum and Diesel oil	32,490	20,706
Coal	12,061	1
Scientific instruments	14,439	13,944

TABLE IV.—*Imports into Peru (Thousands of Soles).*

—	1941, First Quarter.	1940, First Quarter.
Machinery and vehicles	18,153	13,468
Metals and manufactures	9,050	12,116
Chemical and pharmaceutical products	6,226	5,861
Paints, oils, etc.	5,744	5,957
Timber and manufactures	3,008	2,962
Electrical material	2,93	2,423

substantial amount of cotton; if these efforts are successful, they should provide substantial sterling cover to pay for large remittances, at present held up. During the first quarter of 1941, North American goods represented 61 per cent. of Peruvian total imports by value, as against 52·3 per cent. in the like period of 1940; but those from Britain only 8·1 per cent., against 6·6 per cent. Chile's imports from all sources of engineering and similar material in 1940, compared with those in 1939, are given in Table III, herewith; and those into Peru during the first quarter of this year, from all sources, are compared, in Table IV, with the corresponding figures for 1940.

OBITUARY.

MR. A. W. RENDELL.

MR. ALAN WOOD RENDELL, whose death, we regret to announce, occurred on July 29 at his home at Binfield, Berkshire, was a veteran engineer, who after spending 27 years in India, the last 11 as chief mechanical engineer of the East Indian Railway, was for 20 years general manager of the Westinghouse Brake Company, Limited. Mr. Rendell was the third son of the late Captain John Rendell, R.N., of Steyning, Sussex, and was born in 1849. After receiving his education at the Clothworkers' School, Sutton Valence, Kent, he became a pupil of the locomotive, carriage and wagon superintendent of the London Brighton and South Coast Railway, in 1866. On the completion of his pupilage in 1869, he was given a responsible position in the drawing office, but in the following year was placed in charge of the Railway Company's steamers, based on Newhaven and Littlehampton. In 1872, Mr. Rendell left the service of the London Brighton and South Coast Railway to join the staff of Mr. A. M. Rendel as inspector and continued to act in this capacity for two years. In 1874, he went out to India to take up the appointment of assistant locomotive superintendent of the East Indian Railway. He was soon afterwards promoted to the position of district locomotive superintendent and, in 1875, established what we understand were the first training schools and examinations schemes in India for Indian engine drivers and shunters.

In 1877, when only 28 years of age, Mr. Rendell was made chief mechanical engineer of the North-Eastern System of State Railways, Bengal. He was responsible for the organisation of steam ferry

steamers, running day and night in buoyed and lighted channels, in connection with train services, on the Rivers Ganges, Brahmaputra and Teesta. He also designed and placed in service special shallow-draught cargo steamers and barges, and designed and equipped the railway workshops at Saidpur and Dacca. Other works for which Mr. Rendell was responsible were the enlarging and remodelling of the engineering workshops at Kanchrapara and Somastipur and the design and construction of workshops at Secunderabad for the Nizam's State Railway. Mr. Rendell was appointed Chief Mechanical Engineer of the East Indian Railway in 1890 and continued to occupy this position until 1901. He remodelled and enlarged the Jamalpur workshops and also designed and put down, at Jamalpur, an acid open-hearth steelmaking plant. This, which is stated to have been the first of its kind in India, supplied ingots to a rolling-mill shop for thepr oduction of merchant bars of all types and also furnished molten steel for the manufacture of castings for use in the locomotive-building shops. Furthermore, Mr. Rendell was responsible for the building of locomotives and tenders entirely manufactured in India. On his return to England in 1901, Mr. Rendell took up the appointment of general manager of the Westinghouse Brake Company, Limited, and continued in full activity until his final retirement and appointment as consulting engineer to the company, in 1921. He was elected a member of the Institution of Civil Engineers in 1888 and was also for many years a member of the Institution of Mechanical Engineers and of the Iron and Steel Institute. While in India he served in the East Indian Railway Volunteer Rifles, rose to the rank of Lieutenant-Colonel, and gained the Volunteer Officers' Decoration.

MR. JOHN DUNCAN.

IT is with regret that we record the death of Mr. John Duncan, which occurred on July 28, at Chigwell, Essex. Mr. Duncan, who was for many years head of the Engineering Department at West Ham Technical College, and was the author of several well-known text-books, was born in Glasgow on May 22, 1869. He was educated first at Bridgeton Public School, and, in 1881, entered Hutcheson's Grammar School, where he remained three years. In January, 1885, he began an apprenticeship of five years in the engineering works of Messrs. Duncan Stewart and Company, Limited, Glasgow, meanwhile continuing his technical education at the Royal Technical College, then, and until January, 1912, known as the Glasgow and West of Scotland Technical College. After concluding his pupilage in January, 1890, Mr. Duncan entered the drawing office of Messrs. Duncan Stewart and continued with them until October, 1891, when he was appointed senior assistant to Professor W. T. Rowden, who occupied the chair of applied mechanics at the Royal Technical College. Proceeding with his own education, he gained a Whitworth Exhibition in 1892, and, in 1893, obtained the Certificate of the College in mechanical engineering. In September, 1896, Mr. Duncan resigned his position on the staff of the Royal Technical College to take up that of demonstrator in mechanical engineering at University College, Nottingham. After occupying this position for only two years, however, he was elected to the lectureship in civil and mechanical engineering at West Ham Technical College, later becoming head of the Engineering Department. On his appointment, he was entrusted with the task of designing and supervising the installation of the whole of the equipment of the Department. He was a member of the Faculty of Engineering of the University of London, and a "recognised teacher" in civil and mechanical engineering. Mr. Duncan, who retired under the age limit some years ago, was the author of several widely-used text-books, including *Applied Mechanics for Beginners; Mechanics and Heat; Applied Mechanics for Engineers; Steam and Other Engines;* and *Introduction to Engineering Drawing.* He was also one of the authors of the work, *Text-Book of Physics.* Mr. Duncan was elected an associate-member of the Institution of Mechanical Engineers in 1901, and transferred to the class of member in 1908.

LABOUR NOTES.

IN a statement issued on Thursday last week, the Trades Union Congress and the Labour Party jointly declare that while they warmly appreciate the great effort of the Soviet Union in the common struggle against Hitlerism and welcome the fullness of the co-operation which has developed between Great Britain and the U.S.S.R., they see nothing in the situation which would justify them in collaborating with the Communist Party of Great Britain. "On September 2, 1939," the statement continues, "that party declared its determination to resist Hitlerism." A little later, suddenly and without consultation with its rank and file, it reversed this policy. It then declared that the struggle against Nazism was an 'Imperialist War' which must be stopped. Since then, the Communist Party has taken every opportunity to obstruct and weaken the national effort. It has misrepresented and distorted the purpose of the Labour Movement in supporting the fight against Hitlerism. When, on Sunday, June 22, 1941, Hitler, without warning or provocation, attacked Soviet Russia, the Communist Party of Great Britain, once again without consultation with its rank and file, changed its policy. It announced that the struggle was no longer an 'Imperialist War.' The Communist Party during the war has thus again demonstrated its irresponsible and unstable character."

One of the Labour members who took part in the Commons debate on our war production problems suggested that until 100 per cent. efficiency were attained criticism of the Government's plans would continue. What he, no doubt, really meant was that until he and some other critics were satisfied that every effort was being made by all concerned in the production of the instruments and munitions of war there would be no peace, at any rate, at Westminster. It is to be hoped that that was what was in his mind because to long for 100 per cent. efficiency, everywhere and all the time, in so intricate and wide-spread an industrial organisation as our present war effort is, seems to be to pitch our aspirations rather high.

The General Executive Council of the Transport and General Workers' Union state in their annual report that there are now 50 unions in the amalgamation. The total membership at the end of 1940 was 743,349; this compares with 679,360 at the end of 1938 and represents, therefore, a gain of 63,989 in the last two years. The income in 1940 was 980,522*l.* 17*s.* 9*d.*, the highest ever received by the union in any single year, and of that the contribution income amounted to 909,655*l.* 13*s.* 1*d.* Cash benefits paid out during the year amounted to 201,969*l.* 10*s.* 3*d.* Since the amalgamation of 1922, it is pointed out, cash benefits paid out to members have totalled 6,115,822*l.* 18*s.* 5½*d.* The amount placed to General Reserve Fund in 1940 was 175,812*l.* 12*s.* 3*d.* which brings the total net gain since the Bridlington conference to 368,435*l.* 8*s.* 6*d.* At the end of 1940, the General Fund stood at 1,537,464*l.* 2*s.* 8*d.* and other funds at 153,411*l.* 0*s.* 2*d.*

Mr. William Green, President of the American Federation of Labour, is reported to have expressed the opinion to a special Congress Committee, appointed to consider labour problems, that it would be in the interest of the country as a whole to compel workers in the arms industry to save part of their present earnings. "Compulsory savings, now," he declared, "would cushion the shock of post-war unemployment and prevent inflation." He advocated the creation of a savings fund composed of the compulsory savings of the workers with, in addition, a percentage of the profits made by firms in the arms industries.

Judging from the texts of the new agreements reproduced in the May issue of the *Journal* of the American International Association of Machinists—an organisation which is, in the United States and Canada, the equivalent of our Amalgamated Engineering Union—there is a fairly wide margin for savings, compulsory or otherwise, in the earnings of workers. The following extract from a report in the *Journal* bears out that conclusion:—"San Francisco, Calif.—Business representatives E. F. Dillon and Harry Hook report renewal of agreements with 160 machine shops. The agreements continue in effect the eight-hour day, 40-hour week, and double time for overtime and work performed on Saturdays, Sundays and holidays. Hourly wage increases ranging from 10 cents to 25 cents were granted, thereby establishing minimum hourly wage rates of 1 dol. 37½ for tool and die makers, 1 dol. 15, 1 dol. 25, and 1 dol. 37½ for machinists, 1 dol. for specialists, and 87½ cents and 95 cents for helpers. Employees on the second and third shifts are respectively to receive a 10 per cent. and 15 per cent. higher rate of pay. Employees having one year's service with the company are granted a week's vacation with pay."

It is stated in the May issue of the Department's *Review* that the United States Bureau of Labour Statistics has made a study of man-hour and employment data for January, 1940, and January, 1941, covering 17 defence industries. It has also made estimates of the number of additional workers that would have been needed in these defence industries had weekly working hours been continued at a 40-hour maximum without overtime. Despite the fact, it is recorded, that many plants operated on a two-shift or three-shift basis in January, more than 137,000, or 6·6 per cent. additional workers would have been required if the defence industries had not worked overtime. Between January, 1940, and January, 1941, total man-hours in the 17 selected defence industries increased 37 per cent., whereas employment rose only 28 per cent.

Three defence industries showed gains in total man-hours of more than 100 per cent.—aircraft (138 per cent.), ammunition (129 per cent.), and fire-arms (122 per cent.). Increases of more than 50 per cent. were returned in shipbuilding (91 per cent.), engines, steam turbines, etc.—largely as a result of the expansion in the production of aircraft motors—(89 per cent.), machine tool accessories (65 per cent.), machine tools (55 per cent.), and explosives (55 per cent.). Gains in other defence industries ranged down to 13 per cent. for chemicals. Approximately 83 per cent. additional workers, had maximum working hours continued at the rate of 40 per week, would have been needed for six large defence industries—foundry and machine shop products (34,000), machine tools (21,000), machine tool accessories (11,000), electrical machinery (20,000), aircraft (17,000), and brass, bronze and copper products (11,000).

Designed as a means of combating unemployment, a French law provides for restriction of the employment of women, particularly married women. In public administrative departments and enterprises working under concessions, the engagement or recruitment of married women is prohibited, although it is provided that exemptions may be granted in cases where husbands are unable to support the household. Automatic retirement of married women with the grant of a pension is provided for women over 50 years of age in the State services, with the intimation that the practice may be extended by decree to any other public service or concession. Any married women employed in an administrative department may be given leave without pay if her husband supports the household unless there are at least three dependent children. A pension may be granted to such women if they have completed the necessary length of service; if not, they may be given a lump sum equivalent to one month's pay for each year of service.

Up to the end of last month women who were entitled to claim a pension prematurely were at liberty to remain automatically and entitled to receive a pension based on their years of service, with a bonus proportionate to the period which must elapse before they reach the age limit. In addition to the foregoing provisions for the compulsory termination of the services of married women, encouragement is given to women to resign voluntarily in the event of marriage, a bonus varying according to the length of service before the age of 25 being offered up to a maximum of 10,000 francs and on condition that the marriage takes place before the age of 28. Orders have been issued fixing the percentage of posts available to women in each of the administrative departments, bodies or undertakings, and a maximum percentage has also been fixed for women employed in private enterprises (except agriculture).

The United States Court of Appeals for the District of Columbia has decided that the American Federation of Labour acted within its constitutional power when, in 1933, on the instructions of its executive council it ordered that teamsters in the brewery industry should come under the jurisdiction of the International Teamsters' Union. The decision reversed the finding of the lower court which had granted an injunction to the Brewery Workers on the grounds that the American Federation of Labour exceeded its power in transferring beer drivers from the Brewery Workers' Union to the Teamsters' Union. The court of appeal held that the 1933 decision of the Federation did not violate the rights of the Brewery Workers' Union, even although that union had, in 1915, entered into a contract with the Teamsters' Union that brewery drivers should be retained in the Brewery Union. The court maintained that the American Federation of Labour, as the parent body, had a right to determine the jurisdiction of its affiliates; the courts, therefore, should not interfere with activity taken by the Federation in carrying out its 1933 mandate.

ASSEMBLY FACTORY FOR "BEAUFIGHTERS."

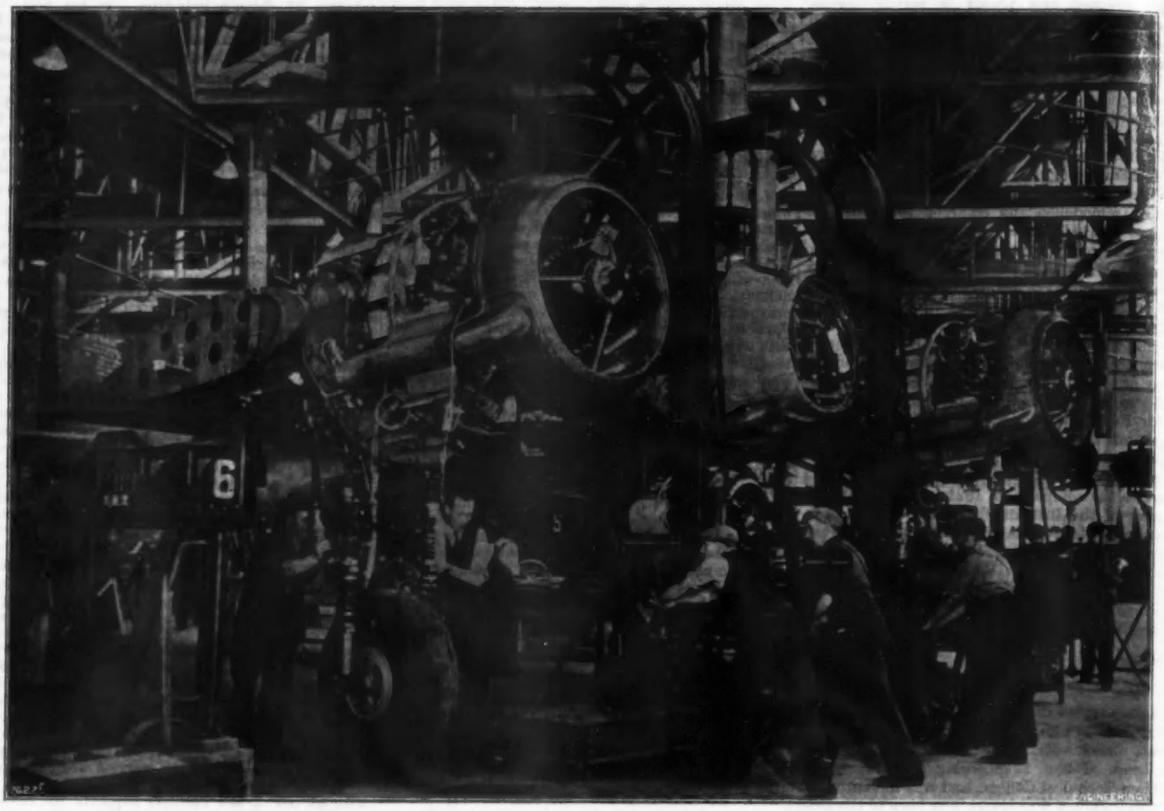


Fig. 5. Removing Partly Completed Machine from Assembly Jig.

THE "BEAUFIGHTER" LONG-RANGE FIGHTING AEROPLANE.

The Beaufighter, some illustrations of which appear on page 110, is a high-performance all-metal mid-wing monoplane, fitted with two "Bristol" Hercules engines. It is designed and equipped as a formidable long-range day and night fighter with exceptionally powerful armament, and accommodation is provided for a crew of two, consisting of pilot and observer. The principal dimensions are :—span, 57 ft. 10 in. ; length, 41 ft. 4 in. ; and height to top of rudder with the aeroplane in the rigging position, 15 ft. 10 in. It has an all-up weight of 21,000 lb. The nominal top speed is over 330 m.p.h. at 14,000 ft. and the disposable load, including oil fuel, armament, etc., is 7,200 lb., which is 34 per cent. of the all-up weight ; it has a nominal range of 1,500 miles. Its armament consists of four 20-mm. Hispano-Suiza cannon, fitted in the fuselage, and six Browning machine guns in the wings. Some of the "nostrils" through which the cannon fire can be seen in Fig. 2, on page 110. The Beaufighter is of all-metal stressed-skin construction with a monocoque fuselage. The main plane is a two-spar cantilever structure made in three sections ; the centre plane, which passes through the fuselage is bolted to it, and to the port and starboard outer planes. The fin and tail plane are all-metal cantilever structures ; and the control surfaces, rudder, elevator and ailerons, are metal structures, with fabric covering.

Two "Bristol" Hercules III engines are installed in nacelles near the outer ends of the centre plane, as is most clearly shown in Fig. 2, on page 110. They are of the air-cooled sleeve-valve radial type, with 14 cylinders in two rows, and are fitted with two-speed superchargers and constant-speed airscrews. They are fitted with long-chord cowlings, the exhaust collector forming the leading edge, and controllable gills are fitted round the trailing edge, which govern the air flow for cooling purposes. The arrangements are best shown in Fig. 3, on page 110. These engines, one of which is illustrated in Fig. 4, page 110, develop 1,400 h.p. for take-off ; 1,365 brake horse-power to 1,425 brake horse-power at 1,500 ft. ; and 1,220 brake horse-power to 1,270 brake horse-power at 15,000 ft. They have a diameter of 52 in. overall, and a cubic capacity of 38·7 litres (2,360 cub. in.). The fuel is carried in four self-sealing tanks, two in the centre plane and one in each of the outer planes. Separate oil tanks for each engine are mounted on the centre plane and an oil cooler is mounted in each outer plane, the cooling air being collected by a duct in the leading edge of the wings, shown in Figs. 2 and 3. The capacity of the four fuel tanks is 550 gallons, weighing 3,960 lb., made up as follows :—Two centre plane fuel tanks, 188 gallons each and two outer plane tanks, 87 gallons each ; the two oil tanks contain 18 gallons each. Electrical starters and hand turning gear are provided.

Two special hatches in the underside of the fuselage are provided for access to the interior ; one between the centre-plane spars for the pilot and the other for the observer, farther to the rear. These hatches swing down to open and entrance is effected by the ladder attached to them. Hand grips and hand rails are also provided. They are opened from the inside by means of a lever. These hatches are also intended for emergency exit by parachute. By a quick release, each door opens so that part of the door protrudes outwards into the air stream beneath the body. This creates a dead-air region through which the crew can drop freely without risk of injury, even in a dive up to 400 m.p.h. Additional emergency exits are provided, consisting of a knock-out panel on the starboard side of the pilot, a hinged window above the pilot, and a hinged hood above the observer. A cabin heating system is fitted, controlled by a lever on the port side aft of the pilot. This operates a rotating louvre which admits hot air to the cockpit from the engine.

The alighting gear consists of three retractable units, hydraulically operated. Two independent under-carriages are fitted under the engine nacelles at the outer ends of the centre plane, into which they retract rearwards, as will be understood on reference to Fig. 3. The tail unit is also retractable forward into a recess in the fuselage. Electrical indicators and a buzzer in the pilot's cockpit indicate the position of the three units. Oleo-pneumatic shock absorber legs are fitted, together with Dunlop pneumatically operated brakes. Automatic safety locks are provided on the under-carriages to prevent retraction when the aeroplane is on the ground. Hand-operated landing pins are also provided for attachment from the ground, and they are fitted with red flags which are visible to the pilot and must be removed before flight.

The flying controls are normal and orthodox in operation. The ailerons and elevators are operated by a spectacle-type handwheel at the top of the usual control column, through chains and cables. Gun firing controls and a brake operating lever are fitted on the spectacle handwheel, the latter being fitted with a spring-loaded catch for applying the brakes for parking. The rudder is operated by pendulum-type rudder pedals in parallel motion, the pedals being adjustable for leg reach. Locking gear for the flying controls is provided for parking the aircraft. Trimming tabs, controllable by the pilot, are set in the trailing edges of the rudder and elevators for directional and longitudinal trimming. A handle fitted with an indicator showing the position of the tab on the starboard aileron is mounted near the pilot's seat, but the tab on the port aileron can only be adjusted on the ground. The trimming tabs on the elevators are controlled from a handwheel at the top of a column mounted on the starboard side in line with the control column and an indicator is fitted showing the position of the tabs. The trimming tab on the rudder is controlled from a handle, fitted with an indicator, mounted in a horizontal position near the base of the instrument panel.

The hydraulic system operates the undercarriage and tail-wheel retracting gear and the split trailing-edge flaps. Pressure is supplied to the actuating jacks by two power-driven pumps, one on each engine. The main relief valve for the hydraulic system is set at 1,200 lb. per square inch. An emergency hydraulic system for lowering the alighting gear and flaps is provided and is operated by a hand pump, fitted under the pilot's seat and operated by a handle on the starboard side of the seat. For use in emergency the handle is extended by pulling upwards on a twist grip and locking it in position. It is provided mainly for servicing purposes on the ground, but can also be used in flight either to operate the hydraulic services,

ASSEMBLY FACTORY FOR "BEAUFIGHTERS."

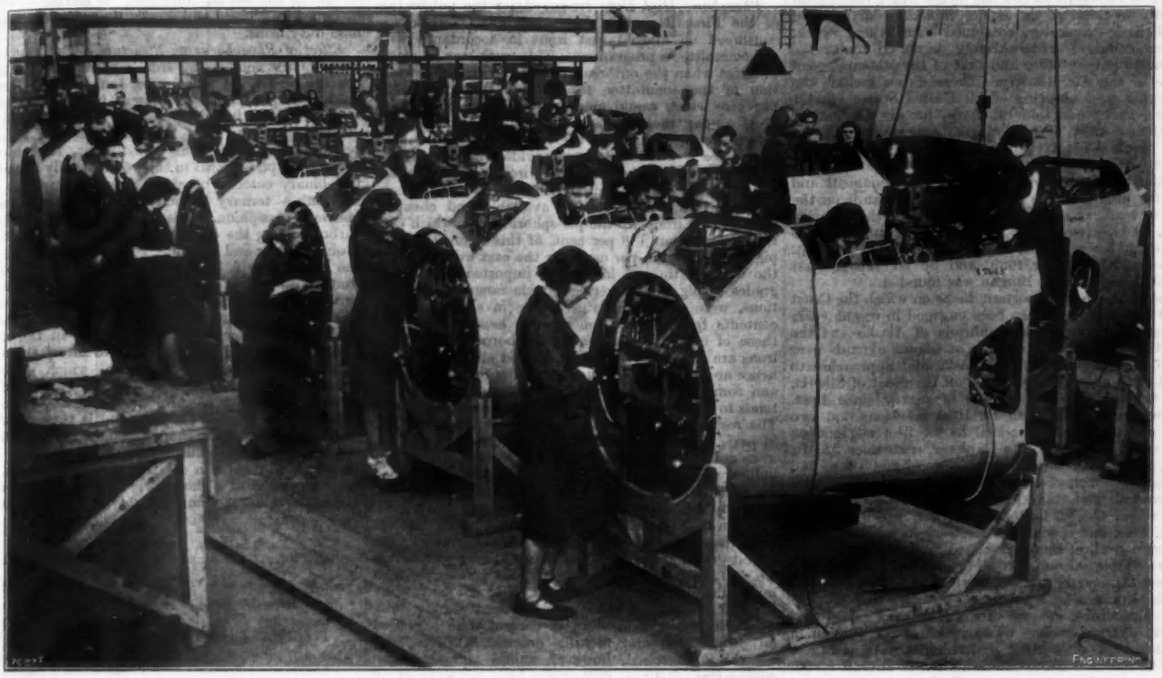


FIG. 6. FITTING FRONT SECTION OF FUSELAGE WITH COMPONENTS.

if the engine pumps fail, or the separate emergency system. The controls for operating the hydraulic system are situated on the port side at the base of the instrument panel and two gauges mounted on the port handrail show the pressure delivered by the port and starboard pumps. Separate controls are provided for the undercarriages and the flaps, both being fitted with indicators to show their positions. They are operated through a selector control lever which should be in the "off" position except when these services are being used. The undercarriage control consists of a lever which operates in the same sense as the movement of the units; namely, up to raise the units and down to lower them. The indicators for the undercarriage units are mounted on the port side of the instrument panel above the hydraulic control levers. When the three units are locked in the retracted position, the indicators show the word "up" on a red background, and when locked in the lowered position, they show the word "down" on a green background. When the units are not locked either up or down, or when the indicators are switched off, black and white dazzle lines are shown on the indicators. If the engine throttle levers are closed beyond about one-third open position, an electrical warning buzzer sounds until the undercarriage units are locked down. These indicators cannot be switched off unless and until the magneto switches are also "off." The control for the flaps also moves in the same direction, namely, down to lower the flaps and up to raise them. The position indicator at the left of the flap control lever shows the position of the flaps, which can be lowered to any intermediate position, between fully up and fully down, by returning the control lever to the gate in the middle of the quadrant, thus shutting off the control valve.

The direction and turn indicators and the artificial horizon are operated by one of two vacuum pumps, which are fitted to each engine. In the event of the failure of one pump, the other can be selected by means of a change-over control on the port side of the instrument panel. The vacuum available is shown on a gauge beside this control. The pressure at the compressor and cylinder should be 450 lb. per square inch and after passing the reducing valves it should be 220 lb. per square inch. The differentially operating brakes for the landing wheels are also operated pneumatically. Power for the electrical installation is derived from a 500-watt generator, driven by the starboard engine, which supplies current at 24 volts for the usual lighting services, landing lamps, engine starting, radio, A.S.I. pressure heads, gun firing, undercarriage position indicators and warning buzzer, fire extinguishers, camera, etc. The wireless installation is mounted in the fuselage between the centre plane spars on the port side and comprises a transmitter and receiver, operated by the pilot by means of remote controls. Intercommunication telephones between the pilot and the observer are provided. Twin landing lamps are fitted in the leading edge of the port wing, as shown in Fig. 3. The dipping of both lamps is controlled by a lever on the inboard side of the two-speed supercharger controls. Navigation, identification and formation-keeping lamps are fitted, controlled by a signalling switchbox on the starboard side of the cockpit which provides for independent or simultaneous use of the upward and downward lamps either through a telegraphic key for Morse or alternatively a steady illumination. Intercommunication signalling between the pilot and the observer is provided by a buzzer and a white light on the observer's instrument panel in the rear fuselage, operated by a push button on the instrument panel. The observer can also operate a lamp on the instrument panel to attract the attention of the pilot. An emergency signalling system is also fitted, which is an entirely independent circuit only used when abandoning aircraft. A push button operated by the pilot warns the observer to prepare to abandon aircraft; and when the warning light on the instrument panel informs the pilot that the observer is ready, a separate switch is depressed, signalling to the observer to abandon aircraft.

Two throttle-control levers and a single mixture-control lever are mounted on the engine-control panel at the left-hand side of the pilot's seat. They are interlocked to prevent the engines from being run on an unsuitable mixture, and the stiffness of the controls can be adjusted. The fuel supply from the four main tanks is maintained by engine-driven pumps. For normal-range flights, the four fuel tanks should be filled and the outer tanks should be used first, the inner tanks being turned off by the fuel-cock controls mounted on the port side of the pilot's cockpit. When the outer tanks are empty, the inner tanks should be turned on. This automatically turns the outer tanks off. The constant-speed airscrew controls are mounted alongside the throttle and mixture-control levers. The two-speed supercharger controls are mounted in another quadrant aft of the throttle and mixture controls on the engine-control panel. The air-intake shutter levers are situated next to them. The adjustable cowling gills are operated by electric motors controlled by switches on the engine-control panel. Red warning lights indicate when the motors are in operation. Carburettor cut-out controls are in a control box with a spring-loaded cover fitted to the top of the front spar on the port side. Control levers have red knobs for the port engine and green for the starboard. The priming pumps and starting magneto switches for each engine are mounted on the nacelle structure above the undercarriage pivot and are accessible from the ground when the undercarriages are down. The fuel in the four main tanks can be jettisoned in an emergency.

The equipment of the Beaufighter is exceptionally complete and includes navigation, identification and formation-keeping lamps; landing flares; auto-recognition equipment; signal pistol; oxygen apparatus; cine-camera unit mounting; stowage for computators, map cases, etc.; fire extinguishers; first-aid outfit, and axe. Emergency rations are stowed in the rear fuselage at the base of the observer's seat. Flying rations and water bottles are also carried. Other equipment provided includes the heating system, airscrew de-icing, oxygen apparatus and Lorenz beam approach equipment. Provision is also made for carrying a four-gallon water tank for desert use.

For the quantity production of Beaufighters, the practice of the Ministry of Aircraft Production is to have the major components of the aircraft made in factories distributed throughout the country, known as dispersal units, and delivered to various assembling factories in which the components are put together and from which the completed aircraft are delivered to the Royal Air Force. The fuselage of the Beaufighter, for instance, is made in three parts: a comparatively short rear portion to which the tail plane, fin, and the corresponding control surfaces are attached, a longer central section, and another short forward portion in which the pilot's cockpit is located. Fig. 6 shows these latter portions of the fuselage being done up and it will be noticed that the work is being fitted mainly by women. As previously mentioned, the wing is made in three sections, and Fig. 5 shows the engines and cowlings mounted on the centre section and one of the retractable undercarriages being adjusted. The partially completed machine is being removed from the assembly jig. There is, of course, a considerable amount of electric wiring and pipe work to be done in the assembly factories, one of which we were able to visit recently. We noticed that thin tubes of fairly large diameter were being bent in a small hydraulic press with wooden formers, faced with fibre to reduce wear. Before bending, the tubes were filled with Cerrobend, which is an alloy having a very low melting point, the alloy being melted out when the bending operation is completed by plunging the tube into a tank of hot water. The aircraft are completed ready for flying at the assembly factories, all measuring instruments being carefully tested and the guns lined up and the machines being delivered ready for service.

THE UNITED STATES COAST AND GEODETIC SURVEY.

THE Coast and Geodetic Survey service of the United States Government carries out duties which correspond roughly to those of the Hydrographic Department of the British Admiralty, combined with others which, in this country, are separately organised under the Ordnance Survey office and that of the Meteorological Office of the Air Ministry. These duties include the surveying and charting of all United States coastal waters, the production of charts for air navigation, and the collection of tidal, magnetic, geodetic and other data required for navigation by sea and air and for a variety of engineering and scientific purposes. The steadily increasing development of the armament and training programme is making record demands on the Survey staff, as is indicated by the fact that, during 1940, the Survey provided 407,186 nautical charts and 463,917 aeronautical charts, a total 21·6 per cent. in excess of that for 1939, and by far the greatest distribution since the Bureau was founded.

One of the most important tasks on which the Coast and Geodetic Survey has been engaged in recent years is that of surveying the peninsula of Alaska and the Aleutian Islands. This group of islands extends over 1,000 miles westward from Alaska and approaches to within 250 miles of the islands off the coast of Siberia, and has now been in process of survey since 1934. The report of the Bureau for 1940 mentions that two new vessels have been added to the fleet engaged on this work. Of these, the Explorer, a steamer 220 ft. long, fitted with turbine machinery of 2,000 h.p. and having a cruising radius of 8,000 miles, has been designed to undertake long voyages in isolated areas. The other, the E. Lester Jones, is a wooden tender, 88 ft. long, and is intended for work in more sheltered waters. Both of these vessels, as well as a number of others employed on this duty, are fitted with the Dorsey fathometer in conjunction with an automatic depth recorder.

A considerable amount of work, of very varied character, was undertaken by the staff of the Bureau in collaboration with other departments. As instances may be mentioned the determination of aircraft speed-trial courses, in co-operation with the Army Air Corps; air photographic surveys to check aeronautical charts, in association with the Air Corps and the United States Coast Guard; the alignment of the track at the new David W. Taylor Model Basin at Carderock, Maryland, in collaboration with the Navy Department; and the plotting of levels in the valley of the Mississippi, undertaken for the Mississippi River Commission. The aircraft speed courses measured were from Wright Field, Ohio, to Scott Field, Illinois, and from the same starting point to Eaton, Ohio; from Denver, Colorado, to Castle Rock, Colorado, and to Tucumcari, New Mexico, and 3-km. courses at Denver and at Fairfield, Ohio.

Eighty-five tide stations were maintained in operation during the year, 41 being on the Atlantic coast, 38 on the Pacific coast, and 6 in the Gulf of Mexico. Thirty-eight of the stations were conducted jointly with other bodies, including the United States Engineers, the Navy Department, the city authorities of New York, Santa Monica and Los Angeles, the Woods Hole Oceanographic Institution, Chesapeake Biological Laboratory, and the University of Washington. Some improvement was effected in the design of the standard type of tide gauge, to reduce the weight and the cost of manufacture; and excellent results were reported with an experimental model of a new type of portable tide gauge. No current surveys were conducted during the year, but a number of current observations were secured by hydrographic parties and in co-operation with other organisations.

Continuous magnetic information was obtained at five observatories, either to improve the magnetic survey or to record the changes in the earth's magnetism. The data so obtained are of value not only in navigation, but also to the land surveyor, the explorer of oil and mineral resources, and especially, in radio communication. The need fo a non-magnetic ship, with which to make similar obserrvations at sea, is stated to be becoming acute; they cannot be obtained from steel ships, and, since the destruction of the yacht Carnegie in 1929, none haae been made. It follows that the values of the magnetic declination, as stated on charts, are becoming progressively less reliable. The seismological branch of the Bureau's work includes the operation of seismographs at four observatories, and co-operation in maintaining seismographs at a number of colleges. Sixty strong-motion seismographs, for recording strong local shocks, were maintained at 52 stations. A number of vibration tests were also made on buildings, and the recording of fault noises in two deep wells was carried on intermittently. Importance is attached to the seismological data collected by the Bureau, in connection with national defence works, as it is recalled that buildings at Mare Island Navy Yard were severely damaged by an earthquake during the Spanish-American War.

HIGH-DUTY CAST IRONS FOR GENERAL ENGINEERING PURPOSES.*

Phosphoric High-Duty Irons.—After the publication of the First Report in December, 1938,† work was continued on alloyed cast irons in accordance with the committee's programme. This work was in active progress when the outbreak of war directed the attention of the committee to those matters within its province which would most assist the national effort. Chief among these was the necessity for making the fullest use of the national resources in phosphoric ores, and hence it was decided to provide engineers with a report on phosphoric irons. The iron ores most abundantly found in the United Kingdom are phosphoric, and hence the most readily available and cheapest pig and cast irons are the phosphoric irons, which contain up to about 1·8 per cent. of this element for the pig and about 1·4 per cent. for the cast irons. Before the war, by the use in part of imported ores, many grades of pig iron, covering a wide range of compositions, were commercially available in all phosphorus contents from the low phosphorus hematite irons to those of over 1·5 per cent. phosphorus. Phosphoric irons are comparatively easily melted and poured, and hence are used in the United Kingdom for the cheapest and commonest castings. As a consequence their use tends to be opposed by engineers requiring strong irons. The responsibility for this should be debited, at least in part, to factors other than phosphorus. Phosphoric irons are also used in the highly developed light castings industry for the sections and sizes used in which they are peculiarly well suited, but such castings are not normally submitted to engineering tests.

When the first national specifications for iron castings were drawn up in 1928, it was considered that the lowest grade, grade C, of British Standard Specification No. 321, calling for 9 tons or 10 tons per square inch minimum ultimate tensile stress, could not be met by irons of the highest phosphorus content commercially available unless a measure of control were exercised on composition and melting practice. Where such control is exercised, however, sound and successful engineering castings containing high percentages of phosphorus have been made for many years, and have been found to be of particular value in engine parts requiring resistance to wear. In fact, data in the First Report show irons containing 0·76 per cent. and 0·87 per cent. phosphorus meeting grade 2 of British Standard Specification No. 786 (1938) (18 tons per square inch tensile) and hence qualifying as high-duty irons. There has been, nevertheless, in recent years, a very definite movement in the United Kingdom towards the use of very low phosphorus irons for engineering purposes and four factors have contributed to this. A marked development has taken place in high-duty irons made from charges carrying high percentages of steel scrap and also of alloyed irons, both of which have tended towards low phosphorus contents. The rapidly growing and technically advanced automobile industry has required strong and dense castings demanding, on account of their comparatively small size and thin section, a relatively high silicon content, with which, as will be seen below, a low phosphorus content is a necessary concomitant if soundness is to be assured. The development of continuous production systems, especially for large outputs of small castings, has encouraged the use of a standard composition low in phosphorus, adopted to ensure uniformity in foundry practice, although not technically necessary for the whole of the output. By this uniformity, however, the fullest advantages of mechanised plants are realised.

These tendencies have undoubtedly influenced practice in the production of larger castings which, as shown below, can be made to yield a dense structure free from shrinkage troubles in spite of a higher phosphorus content, provided their silicon and carbon contents are suitably lowered. Finally, American practice has influenced practice in the United Kingdom, without proper appreciation of the fact that the bulk of foundry pig iron available in the United States carries less than 0·5 per cent. phosphorus, a higher figure being found chiefly in pig irons from the Southern furnaces. The war demands the fullest use of home resources, and hence the necessity has arisen for the use of what can conveniently be called phosphoric high-duty irons, involving the adoption of the highest phosphorus contents consistent with specified strengths and with service requirements.

The object of this report is briefly to indicate the limits to which phosphorus can be used with advantage in engineering castings. It is confined to the consideration of plain grey cast iron not specially processed or heat-treated, without alloy additions, and intended for use in the as-cast condition. A further report will be issued on alloyed and specially processed phosphoric high-duty irons.

Effect of Phosphorus on Structure.—The structure of an ordinary engineering iron consists of a matrix of pearlite or pearlite and ferrite, broken up by graphite flakes. If phosphorus is present in the iron, another structural constituent appears, a microscopically fine conglomerate into one of the two parts of which the phosphorus enters. This constituent, for which the presence of phosphorus in the iron is wholly responsible, is a binary eutectic obtained from what was at solidification, a ternary eutectic of γ-iron, iron carbide, and iron phosphide. This loses more or less all of the carbon during the cooling process, the carbide decomposing to iron and graphite, so that as observed under the microscope it is an intimate mixture of iron and iron phosphide. The iron phosphide is hard and brittle, and confers these properties to some extent on the conglomerate into which it enters. By controlling the composition of a phosphoric iron in the manner indicated below, it is possible so to direct the solidification of the phosphide eutectic—which is the last constituent of the melt to solidify—that the most beneficial or least harmful distribution of phosphide results. The phosphide compound is then distributed as a network or honeycomb throughout the matrix.

Phosphorus, like silicon, lowers the capacity of the melt to hold carbon in solution at solidification, so the carbon content of a phosphoric iron made from normal materials is lower than that of an otherwise similar non-phosphoric iron. As the phosphide eutectic melts at a lower temperature than the remainder of the metal, phosphoric irons solidify over a wider range of temperature than the non-phosphoric irons. This aids the foundry process and assists castings to take a sharp impression of the mould, but it also sets up conditions which may create difficulties resulting in shrinkage defects. A common experience in the founding of irons high in silicon, phosphorus, and carbon is their proneness to internal shrinkage. While the difficulty can be considerably offset by skilful running and gating of moulds, the risk can also be very much reduced if certain limits of composition are not exceeded. These have been determined by recent investigations of the British Cast Iron Research Association, and the maintenance of these limits also favours good mechanical properties.

TABLE I.—*Composition Limits for Adequate Strength and Soundness in Phosphoric Cast Irons.*

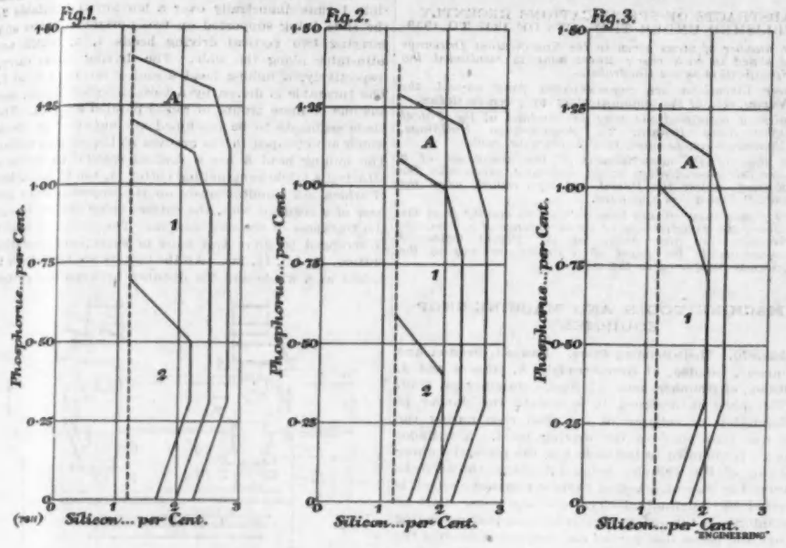
1.	2.	3.	4.
For Grey Cast Irons of		Maximum Percentage of Total Carbon for Reasonable Strength should not exceed	For Soundness, the Total Carbon Content given in Col. 3 is Adequate unless Reduced as Indicated Below.
Silicon, Per cent.	Phosphorus, Per cent.		
Below 1·5 ..	0·3	3·6	—
	0·6	3·5	—
	0·9	3·4	—
	1·2	3·3	—
1·5 ..	0·3	3·5	—
	0·6	3·4	—
	0·9	3·3	—
	1·2	3·2	—
2·0 ..	0·3	3·3	—
	0·6	3·2	—
	0·9	3·1	—
	1·2	3·0	—
2·5 ..	0·3	3·2	—
	0·6	3·1	2·9
	0·9	3·0	2·9
	1·2	2·9	—
3·0 ..	0·3	3·0	—
	0·6	2·9	2·7
	0·9	2·8	2·7
	1·2	2·7	—

The carbon content, referred to above, that a given cast iron is able to hold in solution at solidification, is known as the eutectic carbon content. To ensure adequate (not necessarily the maximum possible) mechanical strength, the carbon present in an engineering cast iron should never exceed this value, and should preferably be below it. The actual figure is influenced by the amount of silicon and phosphorus present, and Table I gives the carbon content for reasonable strength (equivalent to grade A or grade 1 of the specifications referred to below) for any combination of silicon and phosphorus likely to be met with in engineering cast irons. The carbon content

* *Second Report* (*Phosphoric High-Duty Irons*) *of the Research Committee on High-Duty Cast Irons for General Engineering Purposes*, prepared for the Committee by the Reporter, Mr. J. G. Pearce, M.Sc., M.I.Mech.E., and presented for written discussion to the Institution of Mechanical Engineers. Abridged.

† See ENGINEERING, vol. 146, page 745 (1938).

PROPERTIES OF PHOSPHORIC IRONS.



given is 0·2 per cent. below the eutectic carbon figure. For a pure iron-carbon alloy, this is 4·3 per cent. carbon, but is reduced by approximately 0·3 per cent. for each 1 per cent. of silicon or phosphorus present.

So far as internal soundness is concerned, in most combinations of silicon and phosphorus used in engineering castings, the carbon content given for strength will also ensure soundness. In the higher silicon and phosphorus contents, however, it is desirable, for the sake of soundness, for the carbon content to be slightly below that recommended for reasonable strength; and where these values are lower they are given in col. 4 of Table I. In plain grey engineering castings, however, silicon contents below 1·5 per cent., or more than 2·5 per cent., are seldom required, and the castings with which the report is mainly concerned exclude the extremes of very small and very large sizes.

It will be clear from Table I that small thin castings poured in the ordinary way require relatively high silicon and carbon contents to ensure a grey structure; and, to ensure soundness, phosphorus must be kept low. In larger castings, where lower silicon and carbon contents can be used, the phosphorus can be raised without causing difficulty.

Founding Phosphoric Irons.—No special difficulties arise and no additional precautions are required in founding high-duty irons with raised phosphorus contents. Foundries accustomed to the production of phosphoric irons not required to meet strength specifications will find attention to the following points essential, if strength specifications are to be successfully met. Melting practice should be adjusted to give higher melting temperatures, and a higher pouring temperature is required; larger ingates and risers are necessary; a more permeable moulding sand may be required, but additional venting may in some cases prove adequate; some form of control is an advantage, at least in the form of a wedge chill test; and, if possible, chemical, mechanical, and microscopic tests should be carried out.

The Effect of Phosphorus on Mechanical Properties at Air Temperatures.—In order to appreciate the influence of increasing phosphorus contents on strength, for compositions otherwise similar, the general effect of other changes may be briefly reviewed. Within the range of grey irons, mechanical properties—static and dynamic—increase slightly as the section diminishes, and improve with diminishing carbon and silicon contents. The endurance limit in bending fatigue approaches one-half the ultimate tensile stress, and cast iron is relatively insensitive to notch effects and stress-raisers. The effect of dead-annealing is to lower the static properties, but to improve the impact or shock resistance, although these changes diminish for irons of lower carbon and silicon contents. The effect of phosphorus on strength is outlined below, and the conclusions are derived both from results obtained in commercial practice from a wide variety of foundries, and from experimental melts both in crucible and cupola furnaces. They apply to plain cast irons made under controlled conditions, tested and used in the as-cast condition. They do not apply to specially processed, ladle-graphitised (*i.e.*, "inoculated"), alloyed, or heat-treated irons.

In melting ordinary mixtures of pig iron and scrap, the tensile, transverse, and fatigue strengths and transverse deflection normally increase uniformly as phosphorus increases, to a maximum at about 0·35 per cent. phosphorus. As the phosphorus increases beyond this point, these values uniformly decrease in such a way that the figures for irons containing 0·65 per cent. phosphorus are about equal to those obtained for phosphorus-free material. As the phosphorus increases beyond 0·65 per cent., the figures continue to fall. Evidence for this is considerable, and it is the experience of all the leading industrial countries.

It is not practicable to give figures having general application to the change of properties taking place as a result of variation in phosphorus content, because the properties of a given cast iron depend upon many factors other than the percentage of phosphorus, but the foregoing may be taken as generally applicable, irrespective of the figures for a particular case. In order, however, to indicate the degree of magnitude of the change, the ultimate tensile stress may be expected to improve about 2·5 per cent. to 5 per cent. for each 0·1 per cent. of phosphorus added to a non-phosphoric iron, up to a maximum of 0·35 per cent. phosphorus, and then to diminish at a similar rate. The ultimate transverse stress is usually slightly more erratic, and the change is rather less pronounced—about 2 per cent. to 4 per cent. higher for each 0·1 per cent. of phosphorus added, up to the same maximum, followed by diminution at the same rate. The change in transverse deflection is of the order of 2 per cent. to 4 per cent., the variation occurring in a similar way.

The influence of phosphorus on elastic modulus is not pronounced. The fatigue strength may be expected to follow the tensile strength. The Brinell hardness number of plain cast iron increases uniformly with increase in phosphorus content, and a rise of about four points may be expected for each 0·1 per cent. phosphorus added to a non-phosphoric iron. Increased Brinell hardness normally indicates decreased machinability, but the effect of phosphorus on machinability is still an open question. While the phosphide compound is hard, it is very finely divided and assists in breaking up chips at the point of the tool. The influence, on hardness, of changes in carbon and silicon content is also marked. Impact or shock strength diminishes with increase in phosphorus content, and the shock strength of a phosphorus-free iron may be expected to be reduced by about 5 per cent. for each 0·1 per cent. of phosphorus added.

Resistance to wear is influenced by many factors, including structure and composition, soundness, the presence or absence of lubricant, and in particular the part against which the rubbing takes place. Pearlitic structures wear better than ferritic or mixed ferritic-pearlitic structures. Minimum wear is obtained when the difference in hardness between the moving parts is a minimum. When the issue is not complicated by variation in other factors mentioned, it is now generally agreed that, within the limits likely in engineering castings, resistance to wear increases with increasing phosphorus content.

Cast irons are sometimes annealed to facilitate machining. The effect of this process is to transform pearlite into the softer ferrite, and there is a consequent drop in the mechanical properties of cast irons softened to give improved machinability. The phosphide compound, however, is not substantially changed by annealing and the drop in strength on annealing phosphoric irons is not so pronounced as in the case of non-phosphoric irons. Iron containing 1 per cent. phosphorus shows, on dead-annealing, about one-half the drop in strength found in a low-phosphorus iron under similar treatment. The decrease in hardness on annealing is about the same for both high- and low-phosphorus irons.

As stated, the shock or impact strength diminishes as phosphorus increases. Annealing increases the shock strength, and for a given composition the increase is similar for both high- and low-phosphorus irons. The annealing of castings for stress-relief is not followed by any structural change or change in mechanical properties. Heat treatment of the quench and temper type refines the structure and raises the mechanical properties. Neither should be confused with the softening of castings by annealing for improving machinability.

The Effect of Phosphorus on Mechanical Properties at Elevated Temperatures.—When engineering grey irons are submitted to high temperatures continuously, or intermittently over long periods, they are liable to internal and external oxidation, leading to growth and scaling, with a resulting deterioration of mechanical properties. For such conditions, special heat-resisting irons are now available. In some engineering applications, however, it is preferable to use ordinary material and to replace it when necessary, while in others, material has to withstand a limited temperature rise. In general, ordinary engineering grey irons (pearlitic irons) will not be subjected to temperatures exceeding 350 deg. C. Phosphorus does not materially influence liability to growth, but tends slightly to improve resistance to scaling.

As the phosphide compound softens and melts at a lower temperature than the remainder of the metal, the behaviour of phosphoric irons at elevated temperatures is of importance. Experiments carried out by the British Cast Iron Research Association on bars loaded in cantilever fashion, while maintained at a temperature of 850 deg. C., show that as the phosphorus content increases the stiffness or rigidity of the metal also increases. Thus, under a given load, bars with 0·4 per cent. phosphorus showed twice the deflection at this temperature compared with bars of 1·1 per cent. phosphorus. At a given load, the deflection at 850 deg. C. was less for a phosphoric iron than for any other cast iron tested, not specifically made as a heat-resisting iron.

Tests on cast iron at elevated temperatures of sufficiently short duration to avoid creep and growth effects, show that within any limits to which structural engineering castings are likely to be submitted, the decrease in strength with temperature is small. These tests show that as temperature rises to about 200 deg. C. to 300 deg. C. there is a slight fall in strength which is recovered at higher temperatures, so that at about 450 deg. C. to 500 deg. C. the strength is approximately that at air temperature, after which the strength again falls fairly rapidly. This change is true for tensile strength, hardness, and impact strength. Phosphorus does not appreciably modify this, the strength falling slightly in phosphoric irons up to about 200 deg. C. to 300 deg. C., then rising to air-temperature level at 400 deg. C. to 500 deg. C., after which the strength again falls. Phosphorus does not materially alter the thermal expansion of a cast iron, but slightly lowers the thermal conductivity, the amount being about 0·5 per cent. for each 0·1 per cent. of phosphorus added.

Phosphorus and Corrosion.—Ordinary engineering cast irons are, as a general rule, neither intended for, nor submitted to, conditions involving a high degree of corrosion (for which special irons are now available). They offer very good resistance compared with other ferrous materials not specifically made as corrosion-resisting. Where engineering irons are required to withstand a measure of liability to corrosion by acid, the phosphorus content does not materially affect the resistance.

Use of Phosphoric Irons to meet British Standard Specifications.—British Standard Specifications No. 321 (1938) and No. 786 (1938) specify definite tensile and transverse strengths. The strengths obtained in terms of composition—total carbon, silicon, and phosphorus—are given in Figs. 1, 2, and 3, on this page. Variations in manganese and sulphur met with in engineering castings do not influence these results, provided, as is usually the case, that the manganese content is adequate for the sulphur.

For convenience in use, each diagram refers to a specific range of total carbon contents: Fig. 1, 3·0 per cent. to 3·2 per cent.; Fig. 2, 3·2 per cent. to 3·4 per cent.; Fig. 3, 3·4 per cent. to 3·6 per cent. Each diagram marks the specification which a given silicon and phosphorus content may be expected to meet for a

given carbon range. Fig. 1 shows grades 2 and 1 of B.S.S. No. 786, and A of B.S.S. No. 321. Fig. 2 shows grades 2, 1, and A, the fields diminishing as the carbon content increases. Fig. 3 shows grades 1 and A. Compositions outside the A field, but reasonably near to it, may be expected to meet grade C of B.S.S. No. 321. The left-hand vertical boundary line in each diagram is dotted. It is not implied that irons having a lower silicon content than that indicated by this line cannot or do not meet the appropriate specifications; the bulk of the evidence available relates to silicon contents above that represented by the dotted line.

The diagrams should be used subject to the following precautions. As indicated above, they apply to plain cast irons made under controlled conditions, tested and used as cast. They do not apply to specially processed ladle-graphitised (*i.e.*, inoculated), alloyed, or heat-treated irons. They are derived from existing data on the strength of standard test bars, 1·2 in. in diameter, tested in accordance with standard conditions. This bar represents castings having a mean cross-sectional thickness between 0·75 in. and 1·125 in. For smaller castings, the appropriate bar, 0·875 in. in diameter, representing castings between 0·375 in. and 0·75 in. in section, may be expected to yield tensile or transverse strengths of 1 ton per square inch or, in the high-duty range, of 2 tons per square inch in excess of the corresponding figures for the 1·2-in. bar. Conversely, engineering castings represented by the 1·6-in. standard bar, representing castings between 1·125 in. and 1·625 in. section, may be expected to show strengths of a similar order below those of the figures for the 1·2-in. bar. The experience available on the 0·6 in. and the 2·1-in. bars is as yet insufficient to enable results to be expressed generally.

Figs. 1, 2, and 3 are based on actual results, and for strength and soundness the carbon figures given in Table 1 should be followed where these appear to be contradicted by Figs. 1, 2, and 3. As under ordinary manufacturing conditions, high-phosphorus contents will not be accompanied by high-carbon contents, Fig. 3 will be found less applicable than Figs. 1 and 2. A well-made cast iron falling within the limits of composition given on the diagrams should have the strengths appropriate to the field indicated, but anomalies and discrepancies may be found, as the factors affecting the strength of cast iron are many. If the strength figures obtained are below those anticipated, it will normally be possible, by taking appropriate steps, to correct them. Alloyed, specially processed, or heat-treated irons may be expected to yield figures in excess of those indicated. Strengths vary with silicon and phosphorus contents, increasing as the proportions of these elements fall, and it must not be expected that all the irons in a given field will have the same strength. A slight change in composition from one side of a boundary line to another will not make a marked difference in strength. Furthermore, the grades of cast iron specified do not make a continuous series; there is a gap between grade A and grade 1.

Figs. 1 and 2 show that high-duty cast irons capable of being classified as grade 2 of British Standard Specification No. 786 (1938) can be made, containing phosphorus up to 0·5 per cent. to 0·6 per cent. without alloy additions, heat treatment, or special processing. These irons meet the committee's requirements for high-duty cast irons.

CATALOGUES.

Wallboard.—We have received from Messrs. Smeaton Hanscomb and Company, Limited, Hughenden-avenue, High Wycombe, Buckinghamshire, a brochure giving particulars of "Bordex" fire-resisting wallboard, which is usually supplied in sheets measuring 8 ft. by 4 ft. by $\frac{1}{4}$ in. thick.

Electric Lighting.—Messrs. The Edison Swan Electric Company, Limited, 155, Charing Cross-road, London, W.C.2, have sent us a catalogue, describing their "Industra" reflectors and containing data relating to illumination. Included also are particulars of fluorescent lighting and fittings.

Electrical Plant.—We have received from Messrs. Bruce Peebles and Company, Limited, Edinburgh, 5, an export-trade pamphlet intended to serve users abroad as a reference list of their manufactures. The illustrations show typical alternating-current motors and generators, converters, condensers, transformers, etc.

Metal-Melting Furnaces.—We have received from Messrs. Monometer Manufacturing Company, Limited, Savoy House, 115-116, Strand, London, W.C.2, a brochure describing their latest designs of furnaces for melting light alloys, bronzes, aluminium and lead. These furnaces are totally enclosed and arranged for heating by gas or by oil, in conjunction with pre-heated air and, in some cases, automatic temperature control. The capacities range from 150 lb. to 10 tons.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, etc., of the communicators are given in italics.

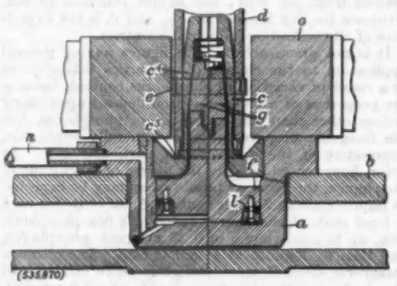
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

MACHINE TOOLS AND MACHINE-SHOP EQUIPMENT.

535,870. Shell-Banding Press. Fawcett, Preston and Company, Limited, of Bromborough, A. Rhodes and J. Gourlay, of Bromborough. (3 *Figs.*) January 24, 1940.—The press is designed to eliminate the danger of deformation or collapse of the shell case during the pressing into place of the driving band. A cylinder block *a* is mounted in the table *b* of the press, the upper portion of the cylinder being internally threaded to receive the base of a hollow tubular mandrel *c* which is divided by longitudinal slots into segments. Part of the interior is tapered at c^4, this tapered part extending above and below that part of the shell case *d* wherein the band *e* is to be pressed on. For this purpose the case is placed over the mandrel and rests on a renewable wear plate c^5 on the enlarged base of the mandrel. Within the lower part of the cylinder block *a* is fitted the base of a ram *f*. A central core of the ram projects upwards into the hollow interior of the mandrel and its upper portion is fitted with a tapered part *g* which corresponds with the tapered interior c^4 of the mandrel. This tapered part *g* is formed as a separate and renewable member having a spigot-and-socket connection with



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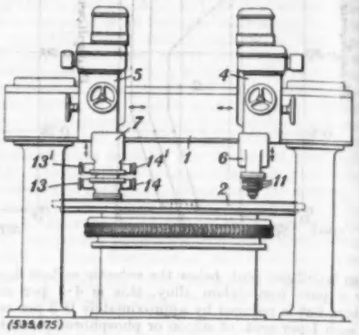
the base part. A compression spring is mounted between a shoulder in the interior of the mandrel and the top of the upper core part. The spring tends to maintain the core in its normal innermost position with the mandrel components in their normal contracted positions. The ram is fitted with a packing ring *l*. Assuming the ram *f* is in its lowermost position, as shown in the right-hand part of the drawing, the shell casing *d* is slipped over the mandrel *c* to rest on the wear plate c^5 and hydraulic fluid is admitted to the cylinder *a* through a conduit *n*. The ram *f* with its core is raised sufficiently for the upper tapered portion *g* to engage the tapered wall c^4 of the mandrel and expand its segments into contact with the shell case *d*, as shown in the left-hand part of the drawing. Simultaneously, the banding dies *o* of the press are forced inwards to press the band *e* into the shell groove, the support given by the rigid core *g* ensuring that the true shape of the shell case is maintained during the banding pressure. Upon release of the hydraulic pressure beneath the ram *f* the mandrel segments return under their inherent springiness to their normal position and the shell case is removed. (*Accepted April* 24, 1941.)

535,875. Machining of Turbine-Blade Roots. Yarrow and Company, Limited, of Glasgow, and G. Strachan, of Glasgow. (1 *Fig.*) February 7, 1940.—The machine is designed for use in conjunction with the method of mounting blade segments and blades in a turbine rotor or casing in which the root of each segment or blade is fitted into a circumferential groove in the rotor or casing, the sides of the root being serrated to engage serrations cut circumferentially in the groove of the rotor or casing. Hitherto, it has been common practice to machine opposite sides of the root in one machine, the base of the root in another machine and serrate the opposite sides of the root successively in a third machine. The latter three operations must be at the same radius as that of the turbine casing or rotor. In the present machine, all the machining and serrating operations are carried through automatically in a single machine. A cross slide 1 runs diametrally over a horizontal turntable 2, the slide being supported on two upright columns and carrying two vertical driving heads 4, 5, which are adjustable along the slide. The driving heads carry, respectively, a milling head 6 and a serrating head 7. The turntable is driven by a variable-speed motor, and has one or more groups of radial parallel grooves. The blade segments to be machined are mounted on stools which are clamped in the grooves at the desired radius. The milling head 6 has a vertical spindle to which is attached a triple gang milling cutter 11, the three cutters of which act simultaneously on the opposite sides and base of a segment root, the cutters being spaced to suit the thickness of the root section. The serrating head 7 is arranged to drive two pairs of superposed serrating cutters, 13, 13^1, 14, 14^1. All the cutters are adjustable in height as a whole and the distance between the cutters



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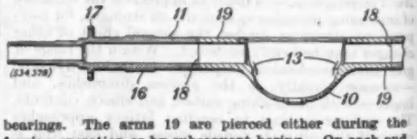
in each pair is adjustable to allow for variations in thickness of the root. The pair of cutters 13, 13^1, project radially outwards relative to the centre of the turntable and the pair 14, 14^1 project radially inwards, the former pair being utilised for serrating segments at their inner edges (this arrangement being for rotor segments) and the other pair for serrating segments at their outer edges (this arrangement being for casing segments). The blade segments are fixed in the stools so that the roots are clear of the stool edges and can pass between the milling and serrating cutters. For rotor segments, the stools on the turntable support the work radially outside of both the milling head 6 and the serrating head 7, while for casing segments these heads are moved radially outwards, and the stools support the work inside them. The stools having been set at the desired radius, the milling and serrating heads are moved along the cross slide 1 and set to mill and serrate the roots at the designed radius of the segment. After the cutters have been set in motion, the turntable is slowly rotated, carrying each segment in turn between the milling cutters and then between the serrating cutters. (*Accepted April* 24, 1941.)

MOTOR VEHICLES.

534,378. Rear Axle. Kirkstall Forge, Limited, of Leeds, and F. R. Cowell, of Leeds. (2 *Figs.*) February 14, 1940.—The invention is a construction of rear axle for cars and lorries whereby it is possible to use a comparatively cheap grade of metal for the central banjo, the large diameter of the axle arms compensating for any reduction in the mechanical properties of the steel. The axle is built up of three separate drop forgings, consisting of a central forging 10 and two end forgings 11. The central forging consists of the basin for the differential and two short integral large diameter arms 19. In the basin are forged the seatings 13 for the differential



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bearings. The arms 19 are pierced either during the forging operation or by subsequent boring. On each end forging are forged spring seatings 16 and a brake flange 17. The three forgings are united to form the composite axle by flash welding at 18. The short arms 19 can be bored quickly and cheaply. The end forgings can be made, if necessary, of a higher quality of steel than the centre forging. Moreover, they may be forged with their outer ends of smaller diameter than their inner ends so as to enable small hub bearings and hub parts to be used. The invention has the advantage that owing to the fact that the axle is built up of three separate forgings, it is possible to avoid the expensive machining operation usually involved by the boring of the full-length axle arms. (*Accepted March* 5, 1941.)